POWER

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The Federated American Engineering Societies Has Been Organized to Mobilize the Engineering Talent of America and Put the Engineer on the Map

ANY society, club or organization the chief object of which is the advancement of the knowledge and practice of engineering and the application of allied sciences, and which is not organized for commercial purposes, is eligible to membership.

All of the other professions appreciate the value of unity, and each has an integral national organization. The engineers are split up into clans and classes. An engineering society is organized for each new application of the engineering art. If the engineers are to become conscious and appreciative of engineers as a class, if the engineers are to become collectively articulate, they must have some instrument through which they can act, some medium through which they can speak with united effort and with one voice upon questions of public and professional concern.

Such an instrument, such a medium, The Federated American Engineering Societies seeks to be. And it *can* be if it has behind it the sympathetic, interested support of the engineers of America.

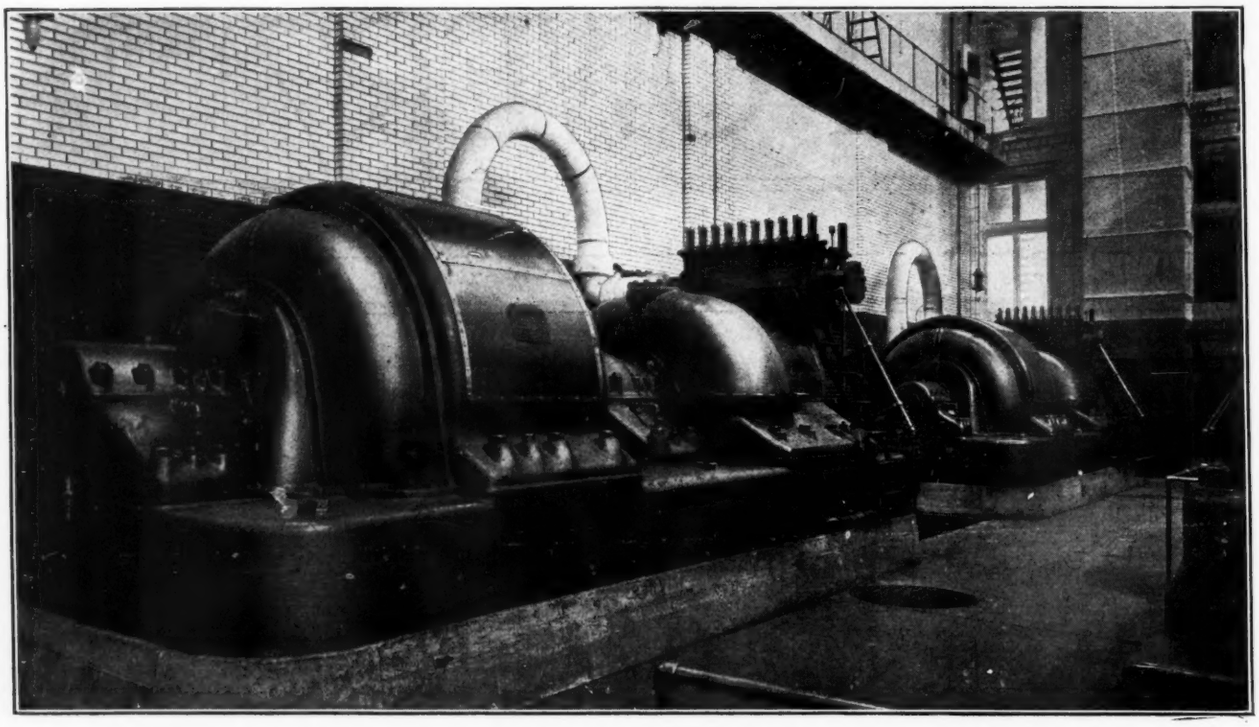
It cannot do this if the engineers who read this say, "It looks all right—let's see how it comes out," and then sit back and see if they can feel any effect.

Its success or failure is going to be spelled by the decision *now* of engineers all over the country whether they will join it or not and how actively they will participate in its activities.

Individual engineers can become connected with it only as members of its constituent societies, but if they feel that it is worth a dollar a year apiece to them to have an organization of this kind constantly working for them, through which they can give expression to their own ideas and effect to their own endeavors, they can urge the organizations to which they belong to join, apply for membership in an eligible society or unite with other engineers in th formation of local organizations which may become member societies of the federation.

The bona fides and high purposes of the movement are assured by the fact that it was inaugurated by, and is being developed under the auspices of, the four great professional engineering societies. The organizing conference has been already held, representatives of societies participating. Engineering Council, Alfred D. Flynn, Secretary, Engineering Societies Building, 29 West Thirty-ninth Street, New York City, is charged with the preparations for its first convention.

What are you going to do about it?



Operation and Adjustment of Turbine Machinery—I What to Watch When Installing Turbines

By EUSTIS H. THOMPSON
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TURBINE-driven sets in small sizes (below 75 or 100 kw.) are usually installed by the purchaser without the services of a trained erector. In most instances this work falls upon the shoulders of the purchaser's engineer. If not already familiar with turbines the engineer's source of information is usually a manufacturer's instruction book or a few words from an interested salesman; perhaps he may be forced to rely on his own judgment and investigation.

Turbine machinery, especially that which runs at five or ten times the speed of a reciprocating engine, requires different treatment from that given to engines. In general a turbine is relatively smaller and lighter, while the parts receiving the mechanical energy from the steam act at higher speeds and lighter thrusts and require stronger materials. When properly adjusted, a turbine requires less attention, runs longer between shutdowns, and for some classes of work costs less and is more economical than an engine of equivalent horsepower. With a smooth flow of power a flywheel is not so necessary as in reciprocating delivery, although the rotating parts often possess more flywheel effect than that found in an engine. On the other hand, a turbine requires more delicate adjustment and more careful handling of its parts, and is more easily put out of service from internal injury.

When an engine is out of adjustment, it expresses its displeasure by knocking or pounding, while a turbine vibrates or roars.

There are some conditions under which an engine set is to be preferred, and in the early days of turbine building there were many "battles" fought in commercial plants to make turbines operate satisfactorily, so that for several years actual comparisons were often unfavorable.

Turbine Needs Accurate Adjustments

Since the turbine has come into its own, however, the equipment found in modern power stations testifies to its advantages for such work. The turbine may now be regarded as an improved form of prime mover, which requires less time and attention from the engineer, but more accuracy and skill in adjusting, and which is more difficult to dismantle, repair and assemble, but which, if properly adjusted and cared for, will require it less frequently.

Small sets are usually of sturdy design, require little adjustment and are easy to repair, depending on their special conditions. In general they can be rolled on skids without special regard to deflecting the bedplate, or picked up by a crane with almost any convenient hitch without fear of undue buckling. So the work of placing them on the foundation is not difficult. Usually, no means are provided by the manufacturer for checking the alignment. So in most cases, locating and grouting can proceed without the refinements of checking the leveling or coupling.

These machines are usually shipped completely assembled, or practically so, and there remains little for the engineer to do except to clean thoroughly and connect up piping. It should be borne in mind that cinders and dust, sand, etc., are likely to be carried into the

machine in transit, therefore all loosely covered bearings, etc., should be carefully inspected. Before the steam and exhaust connections are made, the steam passages should be inspected with a drop-light to make sure that no bolts, tools, pieces of coal or other foreign objects are lodged in them. Oil can now be supplied and the machine made ready for final inspection and starting.

Bedplate Deflected by Weight of Parts

Medium-sized turbine sets, from 150 to 2,000 kw., are more delicate than smaller sets, and erecting men from the manufacturers usually erect and start them. These are as a rule shipped assembled with the possible exception of small parts.

Bedplates are easily deflected by the weights of the parts carried and should be given uniform support in rolling and handling. In hitching to a crane hook, the heavy elements should be supported individually instead of carrying their weight on an unsupported part of the bedplate.

After placing the machine on the foundation, the alignment should be checked and adjusted. The method most frequently used by manufacturers is that of leveling the bedplate. Small surfaces are placed at convenient points along the bedplate upon which a level may be laid. These surfaces are machined so finely that a very sensitive level will show the same inclination when placed in several positions that are parallel. To bring the surface close to a true plane surface it is usually necessary to grind or scrape it. The various portions of the bedplate are lowered or raised by means of wedges until all surfaces show level lengthwise and crosswise. The level should be so sensitive that when placed one-thousandth of an inch out of level in one yard, the bubble will deflect ½ in.

Other Means of Leveling Turbines

Instead of leveling surfaces, spots are often machined on the bedplate upon which a straight-edge should be rested, upon which the level is placed. Wedges under the bedplate are then adjusted as before until the straight-edge may be placed across any two spots, both lengthwise and crosswise, and indicate a true level.

There is still another method of leveling in frequent use where the bedplate is not suitable for either of the aforementioned arrangements. In this case uprights are bolted and doweled to various parts of the set and so machined that their upper ends can be leveled by means of straight-edge and level as in the spot method.

Another well-known means of checking alignment in commercial use is to dispense with leveling entirely and to arrange for the checking to be done on the coupling. The wedges are manipulated until the coupling flanges are parallel, as measured by inserting shim gages or feelers between the flanges, and also central, which condition is measured by placing a small steel straight-edge across the outside surfaces of the flanges. When parallel the shim gages should show the same space between the flanges at all points within one-thousandth of an inch. When central the straight-edge will touch evenly at all points throughout its length on both flanges.

After the set has been correctly checked and properly located, it is ready for grouting, cleaning and completion of assembly.

In erecting large turbo-generator sets the manufacturer supplies a specially trained man unless there is some other special arrangement. In instances where a second-hand machine is purchased or where a set is transferred from one locality to another, the engineer of the plant may be called upon to undertake this work.

Handling the Heavy Pieces

While there are adjustments to be accurately made, steamtight joints, pressed fits, etc., that are far from easy, it often happens that the most trying work is handling the heavy pieces without injury to delicate blades, bearing surfaces, etc. It is most important to plan the job as completely as possible so that all work may progress smoothly and the erecting man may give his entire attention to the work in hand without fear of getting "hung up" and wasting time or labor.

When the machine is received on freight cars, the various parts must be identified and arrangements made for unloading. It is necessary to consider which parts are first needed, which are to be stored until later, where and how they are to be stored and how transported to the foundation when needed. In most plants the cars are brought within reach of the power-house crane; often it is necessary to roll or drag them to the crane; sometimes the plant may be in the process of building with no crane in operation, and may be a considerable distance from the point of unloading, so that the rigging work is the largest problem.

As the unloading proceeds, the shipping lists can be checked. Meanwhile, a shack can be erected close to the job for tools, storing delicate parts, blueprints, and for the convenience of the men. Wedges and blocks for the grouting and special tools can be ordered for the work, to be ready when needed.

First to be placed on the foundation is, of course, the bedplate. If this comes in sections, they should be bolted together securely either by heating the bolts or by driving the wrench with a sledge. To make sure of a good job, this should be checked in all ways before grouting.

Temporary Assembly of Casing

The center lines of the foundation laid down by the designer of the plant should be used in locating the bedplate, and then openings made in the foundation for pipe connections, generator air ducts, drains, etc., should be checked to see if they correspond with the turbine requirements. If the steam and exhaust pipes are already in place, the final connection is up to the erecting man. Sometimes it is better to check these by temporarily assembling parts of the turbine casing, etc., to match exactly with the piping, instead of trusting to blueprints and figuring from the bedplate to the point of connection. A little forethought will often obviate the necessity of moving a 100-ton condenser, or of chipping out a concrete opening at the last minute, or of straining pipe flanges to make pipe connections and causing a bad joint, or other trouble.

The bedplate can now be carefully leveled. As a special precaution the alignment may be checked with a tight line, but this is advisable only in special cases where alignment trouble is suspected or where new parts are to be aligned and doweled.

The best results can be obtained by using a steel wire of 0.008 to 0.010 in. in diameter, such as a piano wire. This should be new and without kinks and should be used as it comes directly off the coil. A piece should

be tested for breaking strain by using it to pick up various weights with a crane. The tension should be produced by suspending a weight of about three-quarters breaking strain.

Aligning Bearing Pedestals

The bearing pedestals, turbine casings, generator and other parts to be aligned should be placed on the bedplate. The bearing pedestals or other parts from which the line is to be located should be carefully bolted and doweled in permanent position. The bearings at each end are used if possible.

The line is now stretched between two rigid supports, such as heavy timbers or convenient columns or pieces of machinery, with the tension as noted before. The line is now moved up or down or crosswise at each end until it is exactly central with the bored surfaces of the end-bearing pedestals or other parts used as a permanent guide. Wedges to suit the rigging are convenient in making small changes in position of the wire. The distance from the wire to the bored surface can be roughly measured with an inside caliper and with final accuracy by an inside micrometer or pin gage. The pin gage is generally the machinist's choice and is made by selecting a piece of wood $\frac{1}{4}$ to $\frac{3}{4}$ in. in diameter, and $\frac{3}{4}$ in. shorter than the average measurement. A pin or needle is driven in at each end so that measuring is done between the two pinheads or needles. The distance is changed by driving the pins in or pulling them out. The position of the wire must be adjusted so that the radical distance to the bored surface is the same at each side as well as above and below. It is not difficult to obtain an accuracy of 0.0005 inch.

After the tight line has been set, the other bearing pedestals, turbine casings, generator, gear housing, etc., can be adjusted so as to be central with the line. They should then be doweled, by drilling and reaming and accurately fitting dowels.

The middle bearing will be lower than the outside bearings by an amount equal to the sag in the wire. This would ordinarily be negligible up to 15 ft. span of wire. It can be checked by assembling the rotary element and opening up the coupling. The middle bearing should be shimmed until the distance between the flanges of the coupling is the same above as it is below, or perhaps 0.002 to 0.006 in. more on top.

Turbine Casing Is Usually Set Low

The turbine casing is usually set low to allow for expansion. It is best, if any question arises in this connection, to get the manufacturer's information on this point. It can readily be settled, however, by making the adjustment that seems best, and then checking the alignment with shaft again, when the machine has been put in service, and correcting to be central under working conditions of temperature. If the shaft is sprung, the spring must be measured, and this should be taken into consideration when centralizing with the shaft.

After the foregoing questions of checking location, alignment, pipe connections, etc., have been settled, the grouting can be poured. While this is hardening, the parts next to be assembled should be cleaned and made ready.

The importance of cleaning is seldom realized by the inexperienced. The practical man knows that grit or sand in a bearing running at high speed can cause considerable damage in a few minutes. A scraped joint, where no gasket is used, is difficult or impossible to make steam-tight when dirt is present. Dirt causes alignment troubles when shims and contact surfaces are not properly cleaned. Cleaning is something of an art. An appreciable skill is required in preparing, with a sharp machinist's scraper, a scraped surface which has been warped by bolt pressure and expansion, and which is covered with sticky dope. Some judgment is required in getting this work done by unskilled and unreliable labor. When large pieces are cleaned, it is a good plan to provide putty knives or old files ground to a dull edge. The work can then be inspected by an experienced man, and filing or scraping done as required.

Delicate parts which are being assembled should be covered with a tarpaulin or other shield each night to prevent dust settling from the air, and solid particles, such as bolts or nuts, finding their way in. The steam passages must be continually guarded and inspected.

The most difficult part of the assembling is usually the turbine rotor and casing. It is most important to have reliable men to watch different parts as the lowering is done.

The remaining parts to be assembled, which include generator, packing casings, steam chest, valve gear piping, etc., often require much painstaking work and represent a large part of the job.

Chapters to follow will deal with steps that the engineer may be called upon to make to produce a so-called "perfectly" running machine. Perfection is usually too expensive for commercial practice, but from a practical point of view there is a state that is called perfection which is the only goal worth while for turbine-machinery erectors and which can usually be reached by a little forethought and thoroughness rather than by laborious and expensive means.

Don'ts for the Diesel Engineer

Don't regulate the compressor discharge pressure by using a relief valve. Put a throttle valve on the compressor suction line.

Don't grind the fuel-pump valves too often. Filtering the oil will reduce valve cutting.

Don't fail to recheck the valve timing after grinding a valve.

Don't think you are getting correct ignition. Use an indicator and know.

Don't overlook jumping the piston at each shutdown to note the play in the rod bearings.

Don't carry the cooling water below 120 deg., nor higher than 150 deg.

Don't feel that the indicator is the steam engineer's toy. The Diesel operator needs it fully as much.

Don't let the pipe trenches fill with dirt simply because it will be out of sight.

Don't carry an excessive air pressure—cylinder knocking is frequently due to this.

Don't start redesigning the engine as soon as it is installed.

Don't be satisfied with less than two circulating-water pumps and an auxiliary air compressor.

Don't flood the cylinders with lubricating oil; an excessive amount will carbonize on the cylinder walls.

Don't be satisfied if the engine exhaust is dark. Anything other than a clear exhaust proves that the engine is not properly tuned up.

The British Thermal Unit and the Mechanical Equivalent of Heat

By F. R. LOW

THE British thermal unit, or B.t.u. as it is commonly abbreviated, is the English unit by which quantities of heat are measured. Heat quantity is quite a different thing from temperature. If a cupful of water is dipped out of a barrelful, they will both have the same temperature, but there is a good deal more heat in the barrelful than there is in the cupful. There is more heat in a pint of water at 32 degrees Fahrenheit than there is in a teaspoonful at 212 degrees.

The British thermal unit is that amount of heat which is required to increase the temperature of one pound of water one degree Fahrenheit.

This definition, commonly given, is well enough as far as it goes, and tells as much as anyone needs to know about the B.t.u. in order to use it intelligently and to the degree of accuracy required in ordinary engineering calculations; but it is not precise.

What Is a Pound?

The pound is the English unit of weight. Masses or quantities of matter are weighed by comparing the attraction which exists between them and the earth with the attraction between the earth and standard weights, as in a scale balance or upon a spring scale that has been calibrated with standard weights. Our early weights and measures were brought over from England, and there got to be such a diversity among those in use at the different custom houses and elsewhere that the necessity of a standard became apparent. The Treasury Department, therefore, between 1830 and 1835 adopted an avoirdupois pound based upon the standard Troy pound brought over from England a number of years before and deposited in the Mint at Philadelphia for the express purpose of serving as a standard for American coinage.

In 1866 Congress made the metric system lawful in the United States and fixed the values of the new system in terms of the system in general use.

In 1875 a Metric Convention was signed at Paris establishing an International Bureau of Weights and Measures to be supported by the countries that signed the convention. These included all the principal countries of the world, one of which was the United States. France set apart, in the park of St. Cloud, near Paris, a plot of ground which was declared neutral territory and dedicated to the use of the new bureau. The bureau undertook to prepare accurate copies of the standard meter and kilogram in the French archives. These were completed and distributed in 1889. Those falling by lot to the United States were Meters Nos. 21 and 27 and Kilograms Nos. 4 and 20. On April 5, 1893, the Superintendent of Weights and Measures, with the approval of the Secretary of the Treasury, decided that the international meter and kilogram would in the future be regarded as the fundamental standards of length and mass in the United States both for metric and for customary weights and measures.

The United States prototype meter and kilogram now in the possession of the Bureau of Standards, into the keeping of which all the property of the Office of Weights and Measures passed with the establishment of the Bureau in 1901, are shown in Figs. 1 and 2 respectively. The relation between the standard meter and the Imperial yard which had been set by the act of 1866 was by chance the exact relation within the error of observation. The act fixed the kilogram as equal to 2.2046 pounds avoirdupois. The more exact value since determined and now used is 2.204622.

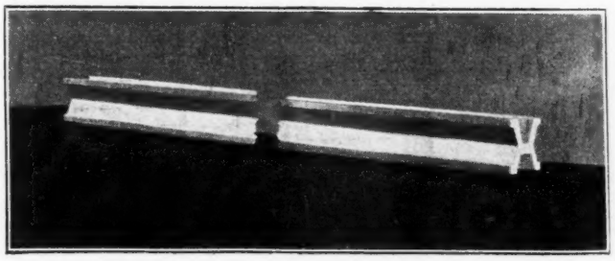


FIG. 1. PROTOTYPE METER. STANDARD MEASURE OF LENGTH IN THE UNITED STATES

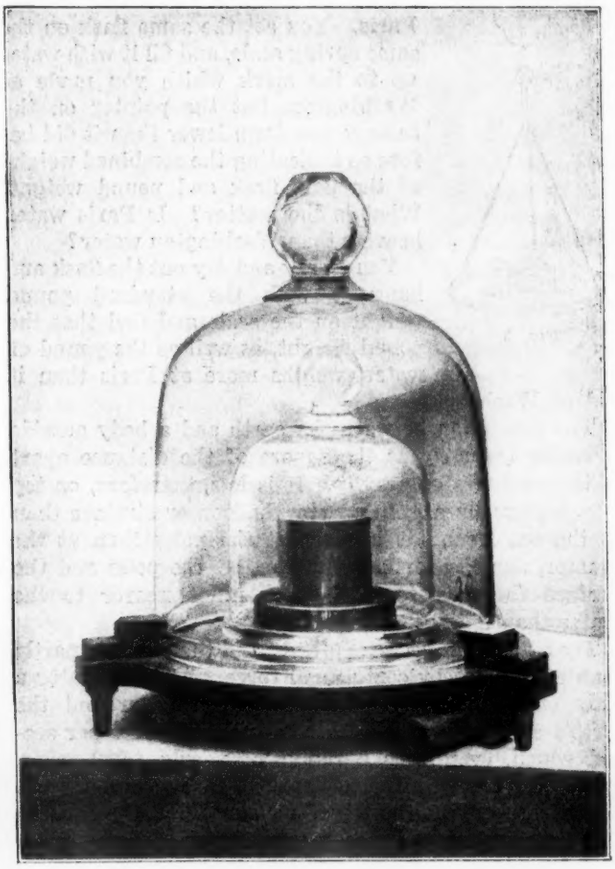


FIG. 2. PROTOTYPE KILOGRAM NO. 20 STANDARD FOR MEASURES OF WEIGHT IN THE UNITED STATES

The pound, then, is equal to $\frac{1}{2.204622}$ of the standard kilogram preserved at the International Bureau

of Weights and Measures at St. Cloud, itself as close a copy as it was possible to make of the original meter in the archives of France, and reproduced with the utmost attainable exactness in the two copies preserved by our own Bureau of Standards.

Weighing a Pound

We have now a definite, positive value for the pound of mass, but it is not so simple a matter as it seems to weigh out a quantity of another substance that will have *precisely* the same mass as the standard weight.

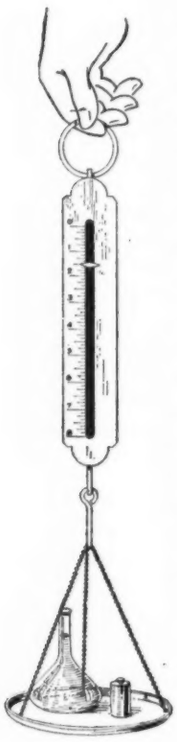


Fig. 3

Suppose we suspend a flask upon a spring scale with a standard pound weight beside it, as in Fig. 3. Note the position of the pointer, remove the pound weight and pour water into the flask until the pointer returns to the same point. You now have a pound of water in the flask. Mark the water line at the neck.

Suppose you had done this at the Bureau of Standards in Washington and later you tried to weigh out a pound of water at the International Bureau of Weights and Measures near Paris. You set the same flask on the same spring scale, and fill it with water up to the mark which you made at Washington, but the pointer on the scale comes down lower than it did before as indicating the combined weight of the pan, flask and pound weight. What is the matter? Is Paris water heavier than Washington water?

You empty and dry out the flask and hang it with the standard pound weight on the scale and find that the pound weight, as well as the pound of water, weighs more at Paris than it did at Washington.

The attraction between the earth and a body outside it varies inversely as the square of the distance apart of their centers of gravity. It is less, therefore, on top of a high mountain, in a flying balloon or airplane than at the sea level. It is more at the poles than at the equator, for the earth is flattened at the poles and the surface there is some thirteen miles nearer to the center than it is at the equator.

The attraction between a body and the earth is partly counterbalanced by centrifugal force. At the equator a body on the earth's surface is whirling around the earth's axis with a velocity of some 1,500 feet per second which, even with a radius of nearly 4,000 miles, produces a considerable tendency to throw the body off. Further, a body on the top of a mountain at the equator is going faster and has a greater centrifugal force than a body at the level of the sea. Here is another reason why altitude may affect the attraction. At the poles there is no angular velocity and no centrifugal force, and so a body at a pole would be attracted toward the earth's center more strongly both by reason of the lesser distance between its center of gravity and that of the earth and of the absence of centrifugal force. And so the nearer we get to the poles and the lower we get upon the earth's surface, the more a body would weigh on a spring scale.

But the mass as determined by comparison with standard weights on a pan balance would be the same at all altitudes and at all degrees of latitude, for although the attraction between the earth and the body to be weighed would be greater at higher latitudes and at lower altitudes, the effect upon the standard weights would be the same and the body would balance the same standard mass wherever the weighing process took place.

This so far as altitude and latitude are concerned. It is not strictly true on account of another consideration.

Imagine a weight to be suspended upon a spring scale, as in Fig. 4. Note the position of the pointer. If the weight were immersed in water, as in Fig. 5, the pointer would rise, showing that the weight was not pulling so hard upon the spring.

The weight is buoyed upward by the water. The flotation force is equal to the weight of the volume of water displaced by the immersed body, and the scale will read lighter by an amount equivalent to the weight of that amount of water. The effect would be the same if the entire scale were immersed, as in Fig. 6.

How about the pan balance? Suppose a pound of wood were weighed upon it and then the whole thing were immersed in water. The wood would float off and apparently weigh nothing. Suppose we weigh something that weighs more than an equal volume of water but less than an equal volume of the metal from which the weights are made, like a piece of coal, for instance, the weights being of brass. If we put enough coal into one pan to just balance the weight in the other when

Fig. 4

Fig. 5

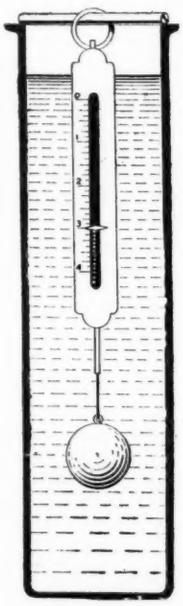


Fig. 6

the scales are in the air, as in Fig. 7, the pan holding the coal will rise and the pan with the brass weight in it will sink when they are immersed in water, as in Fig. 8. The lifting effect on the coal pan will be equal to the weight of a volume of water equal to the volume of the coal. The lifting effect upon the weight pan will be equal to the weight of a volume of water equal to the volume of the weight. The volume of the coal is greater than that of the brass weight, the lifting effect upon it is greater, and the scale is thrown out of balance.

The effect would be the same in kind, though not in degree, if the scales were immersed in a tank of some heavy gas like CO_2 instead of in water; and, although it would take a very delicate balance to show it, there would be a difference in the mass required to balance a standard weight in dense air or in rarefied air, in air at the sea level or at the top of a mountain, in air when it is dry and dense and the barometer is high or when it is charged with the vapor of water and the barometer is low. If the last degree of refinement were necessary, the weighing would have to take place in, or be referred to, a vacuum or to a given medium, as air, at a given pressure and at a standard temperature, for the volumes of the standard weights and the substance weighed would not be likely to change in the

FIG. 7

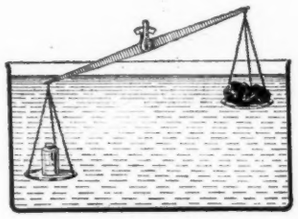


FIG. 8

same proportion with change of temperature. Worcester's dictionary says that the standard pound of the United States is equivalent to the weight of 27.7015 cu.in. of distilled water at 62 degrees F. the barometer being 30 inches and the water weighed in air with brass weights. The foregoing explains why all these conditions are necessary.

WEIGHT AND MASS

The terms weight and mass are used carelessly and interchangeably for the quantity of matter that is in a given body (which is the same regardless of altitude or latitude or temperature or environment) and for the attraction that exists between the body and the earth. If we use the verb "to weigh" to mean to weight down, to pull, we can rightly say that a body will weigh more at the pole than at the equator even in the pan balance, for the standard "weights" with which it is measured would weigh more there too, but only just as much more as the body does, so they would continue to balance each other although each *weighed* more.

We cannot, then, measure the mass of a body, the amount of matter that there is in it, by its weight, using the word weight in this sense, without taking a lot of other things into consideration. But a pound of mass means a mass equal to that in the standard pound weight. This is the same everywhere and always, and when a definition like this says "a pound of water," it means a very precise and definite quantity. In the light of all these considerations the old saying, "A pound's a pound the world around," takes on a new significance.

WHAT IS A DEGREE FAHRENHEIT?

You may be told that the difference between the boiling and freezing points of water is divided, on the Fahrenheit scale, into 180 equal parts and each of these is a degree Fahrenheit.

Water may freeze at 32 degrees Fahrenheit and it may not. It probably would if you gave it time enough, but you can hold a vessel of water for a considerable time at 32 degrees or even below without freezing it. But put ice, enough of it, into a vessel of water in which it will melt, and the temperature of the water will go down to a certain point and stay there as long as enough ice is kept melting in it to keep it there. It doesn't matter how much ice you put in, you cannot get it any cooler, and it doesn't matter how much heat you apply to it, if you keep ice melting in it fast enough to take up that heat it will not get any hotter. Ice melts at a certain fixed temperature, and that temperature is the zero of the centigrade scale and the 32-degree point of the Fahrenheit scale.

WHAT IS THE BOILING POINT OF WATER?

The boiling point of water depends upon the pressure under which it is heated. If heat is applied to a vessel of water, the temperature will rise to a certain point and then it will become stationary and remain so until the water boils away. It does not matter how much heat you apply, you cannot get it any hotter. But this point depends upon the pressure under which the process is conducted. In a vacuum of 26 inches the water will not get above 125 degrees Fahrenheit. In a boiler under 150 pounds pressure, absolute, it will get up to 358.5. The boiling point, 212 deg. at atmospheric pressure, is what is meant.

WHAT IS THE ATMOSPHERIC PRESSURE?

But what is the atmospheric pressure? It is greater at sea level than on a mountain top; it is greater at the same place when the air is dry than when it is full of water vapor, as is shown by the variation in the height of the barometer from time to time in the same location. So we have to have a standard atmospheric pressure, and it has been fixed at that pressure which will support a column of pure mercury 760 millimeters in height, the temperature of the mercury being that of melting ice, zero degrees centigrade, or 32 degrees Fahrenheit.

So we have as a precise definition of the Fahrenheit degree $\frac{1}{180}$ of the difference between the temperature of melting ice and the highest temperature to which pure water can be heated under a pressure that will support a column of mercury 760 millimeters in height, the mercury being at the temperature of melting ice and the water boiling. The temperature of melting ice is called 32 degrees and that of the boiling water under 760 millimeters pressure $32 + 180 = 212$ degrees.

And it is said that the B.t.u. is the amount of heat required to raise the temperature of one of those standard pounds of water through one of these degrees.

HEAT REQUIRED DIFFERENT FOR DIFFERENT DEGREES

But which degree? It may not—in fact, it does not—take as much heat to raise the temperature of a pound of water one degree in one part of the scale as in some other part.

The amount of heat required to raise a pound of water one degree is called its specific heat. The diagram, Fig. 9, shows how Professor Marks and Doctor Davis assumed this specific heat to vary in computing their tables of the thermal properties of steam. You see we should get a different value for the B.t.u. if we made it the amount of heat required to raise a pound of water from 39 to 40 degrees, the point of its maximum density, as was the practice of some physicists, or at 62 degrees, as was the practice of others, or at

15 Centigrade as was European practice, or at some other point. This is one of the things that makes the difference between the steam tables of various authors. The most advanced practice is to use the average specific heat between 32 and 212 degrees. Defined in this way, then, the British thermal unit is $\frac{1}{180}$ of the amount of heat required to raise a standard pound of water from the temperature of melting ice to the temperature at which it will continue to boil under a pressure

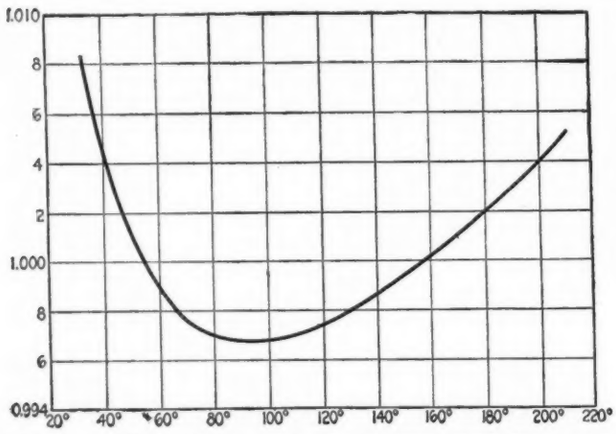


FIG. 9. THE SPECIFIC HEAT OF WATER BETWEEN THE MELTING POINT OF ICE AND THE BOILING POINT OF WATER AT ATMOSPHERIC PRESSURE. THE AVERAGE VALUE BETWEEN 32 AND 212 DEG. EQUALS UNITY

of 760 millimeters of mercury—if we want to be very precise, the mercury to be at 32 degrees and to have a specific gravity of 13.59593.

The Mechanical Equivalent of Heat

Heat and work are interconvertible. The steam engine, for example, converts heat into work and the work is reconverted into heat in the friction of bearings, the cutting of metals by tools, the overcoming of electrical resistance, etc.

The "mechanical equivalent of heat" is the amount of work that would be done or the amount of energy that would be generated by the conversion of a certain amount of heat.

The mechanical equivalent of the B.t.u. is the amount of work or energy corresponding to one British thermal unit. Joule in 1843-50 gave for this value 772 foot-pounds. Professor Rowland in 1880, with more refined methods of experiment, found it to be higher and 778 was generally adopted. The latest determination indicates that it is between 777.5 and 777.6 foot-pounds.

But What Is a Foot-Pound?

The foot-pound, you are likely to be told, is the amount of energy required to lift a pound weight through a vertical distance of one foot; but, as we have seen, this would be more difficult at sea level than at an elevation, and at a high latitude than at the equator. The foot is definitely fixed as one-third of a standard yard, but it is still necessary to have a specific definition for the unit of force.

The generally accepted definition is that it is the pressure exerted by a standard pound in vacuo at a place where gravity has an acceleration of 980.665 centimeters per second per second, this value of gravity being that adopted by the International Committee of Weights and Measures. The "poundal" is the force which, acting upon a mass of one pound for one second, will produce a velocity of one foot per second.

The metric unit of force is the dyne. It is defined as that force which, acting on a mass of one gram for one second, produces a velocity of one centimeter per second.

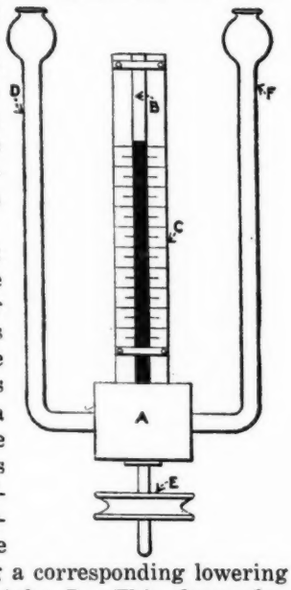
The metric unit of energy is the erg and equals the energy developed by a force of one dyne acting through one centimeter.

The metric unit of heat is the calorie and equals the amount of heat necessary to raise the temperature of one kilogram of water one centigrade degree (in which case it is called the "large calorie") or one gram of water one centigrade degree, in which case it is called the "small calorie." The part of the scale generally used is 15 to 16 or 16 to 17 degrees, but present practice favors the "mean calorie," which is $\frac{1}{100}$ of the heat required to raise one gram (or one kilogram according to whether the small or large calorie is meant) of water from 0 to 100 centigrade.

Simple Speed Indicator

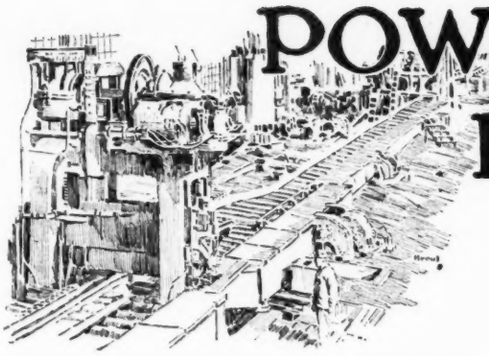
By H. Williamson

In a large steel works in Canada, there is in use an ingenious speed indicator designed as shown by the accompanying illustration, in which *A* is a brass box; *B* is a glass tube, open at the top and communicating with the box *A* at the bottom end; *C* is a graduated scale, the figures denoting revolutions per minute; *D* and *F* are two brass tubes open at the top or bulbed end and also communicating with the box *A*; *E* is a pulley by which the instrument is driven, the vertical shaft being mounted in a suitable bearing.



The operation is as follows: Mercury is poured into the instrument through either tube, *B*, *D* or *F*, until it rises to the top or zero end of the scale. If the instrument is now rotated by means of a belt on the pulley *E* to the shaft whose speed it is desired to know, the centrifugal force drives the mercury from the box *A* up the brass tubes *D* and *F*, causing a corresponding lowering of the column in the glass tube *B*. This depression varies with the speed. The instrument is used only for moderate speeds and is a permanent fixture on the engine frame. It is remarkably sensitive.

On merchant ships built during the past few years, a refrigerating plant of ample capacity is always found. On cargo ships this is about two tons per 24 hours. Ammonia compression, ethyl chloride, CO_2 and SO_2, systems are the rule, with preference for SO_2 in the Shipping Board vessels. Steam drive is being displaced by motor drive. The dense air system has until recently held the field in the Navy. CO_2 systems are now installed on practically all new ships except destroyers, where ethyl chloride and SO_2 systems are found, with a few of the CO_2 type.



POWER DRIVES FOR ROLLING MILLS

By

W. O. Rogers

Several types of shears are described and illustrated. Some are simple in design, and others are massive and somewhat complicated. Plate and jobbing mills, structural, sheet and tin-plate mills, also wire-rod mills are briefly described.

AMONG the important machines used in rolling mills are the shears that shear the metal into proper lengths. Perhaps the simplest is the belt-driven lever shear used for shearing cold metal. It consists of a heavy bed on which an oscillating jaw is pivoted. One end carries the cutting plate, and the other end carries a crankpin, the crank of which connects with a pin carried by a large gear. This gear meshes with a pinion on a flywheel shaft, the latter being driven by a belt in the old machine and by motors in the more modern type (see Fig. 1). When a motor is used, it is gear-connected to the flywheel shaft. Some of these lever shears have compound drives; that is, the motor is geared to a flywheel shaft, which is geared to a second-motion shaft, the latter carrying a pinion meshing with a geared shaft that gives motion to the shear. Another design of lever shear is made with compounded shaft, but is equipped with a friction-clutch drive. Many of these lever shears are covered with metal casings to prevent accidents. The average size shear is driven by about a 25-hp. motor of the induction type and is capable of cutting cold steel sections up to 7 x 7 in. square.

In tin-plate and sheet mills a different type of shear is used for squaring up the sheets. They are of various sizes up to 180 in. in width, and in later designs are motor-driven. They are designed for cutting thin sheets or stacks of tin plate $\frac{3}{16}$ in. or less in thickness. The shear is actuated by crankrods, that receive motion from two or more eccentrics carried on a shaft.

The shears used in conection with slab and billet mills are of a different character and because of the heavy service are of extremely rigid construction. Fig. 3 shows a 3,600-ton capacity steam-hydraulic shear used for shearing slab from a slabbing mill. The thick slab of steel comes from the rolls of the right thickness, but it is in long sections. While hot the piece is run on rollers to the shear, and the slab is there cut into smaller ones. These are afterward reheated and rolled into plates, etc.

The hydraulic shear is perhaps the simplest piece of hydraulic apparatus in the steel mill. It consists of a heavy frame carrying at one end, in a suitable housing, a knife blade, and at the other end a cylinder. A piston rod carries another knife blade, and the piston works this blade up and down, producing shearing action between the blades. Steam acts on top of an intensifier piston and forces the piston rod into a hydraulic cylinder, thereby producing the pressure required for shearing. With this arrangement there are two hydraulic systems used. One is a closed system between the cutting cylinder and the intensifier, and the other, the regular mill system, is connected through suitable valves to the cylinder for the return stroke. By using the steam intensifier, the expansive power of the steam is utilized, and it is possible to get a working pressure of 6,000 lb. per sq.in. The capacity of this type of shear ranges from 300 tons up to 3,600 tons. The larger sizes are equipped with multiple cylinders for various pressures for cutting different sizes of slabs. Hydraulic bloom shears are made either up-cut or down-cut.

Another type of shear is shown in Fig. 5. It is motor-driven, and the huge gearing indicates its cutting strength. As the bloom comes from the mill, it is cut up into smaller pieces and shoved to the right by the manipulator shown on top of the roll train. The pieces

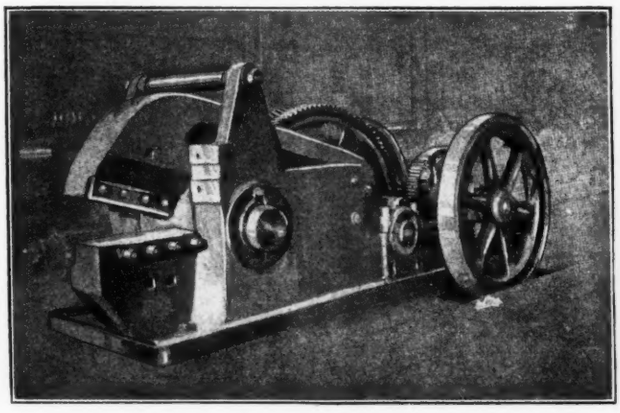


FIG. 1. ONE TYPE OF LEVER SHEAR

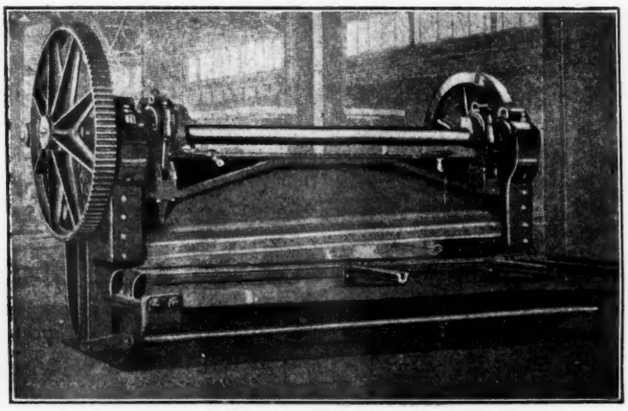


FIG. 2. MOTOR-DRIVEN SQUARING SHEAR

are then removed to be reheated and rolled into the desired product. Bloom shears are built for shearing any size of bloom. They are generally motor-driven for shearing blooms up to 14 in. square, but when larger blooms are to be sheared, hydraulic shears are best.

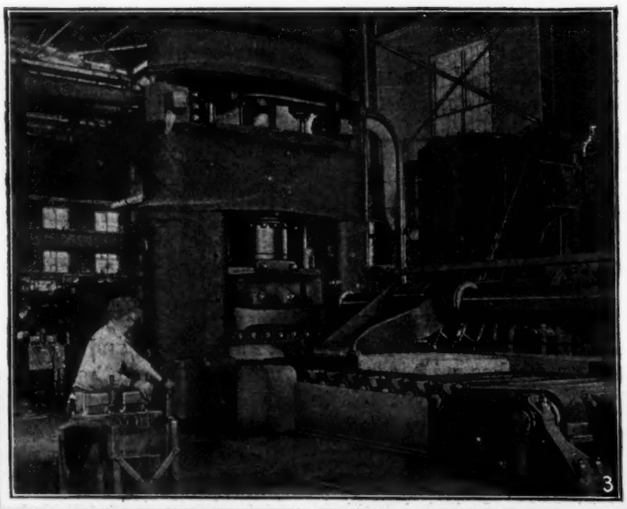
In Fig. 4 is shown a 44-in. reversing blooming mill with a slab shear and billet shear in the foreground. These are hydraulically operated. To use a popular expression, these shears cut through the hot metal as easily as a knife cuts through a piece of cheese. After passing the shears, the steel pieces are reheated and rolled into rods, plates, sheets, and a hundred-and-one products. The mills used in working up these metals are much smaller than the blooming, billet and plate mills, and are arranged with roughing and finishing stands, each consisting of two or three rolls. One of the largest, if not the largest, shear in the world is at the Lukens Steel Car Plant, Coatsville, Pa. It is of the hydraulic type, and the knife is 215 in. long and has a shearing capacity of 2 in. thickness. It is used with a 204-in. plate mill, the largest in the world. One of the simplest mills is that used in rolling tinplate sheets or bars. It is generally made with two stands, two smooth rolls in one stand, although three-high stands are also used. Fig. 8 shows a structural mill of the former type, and Fig. 9 shows a bar mill of the latter. In the two-high mills the top roll is carried in bearing blocks that are moved up and down for roll adjustment by means of a double-pitch screw that is turned by means of gears and an adjusting wheel or adjusting levers which are used to turn the screw either up or down.

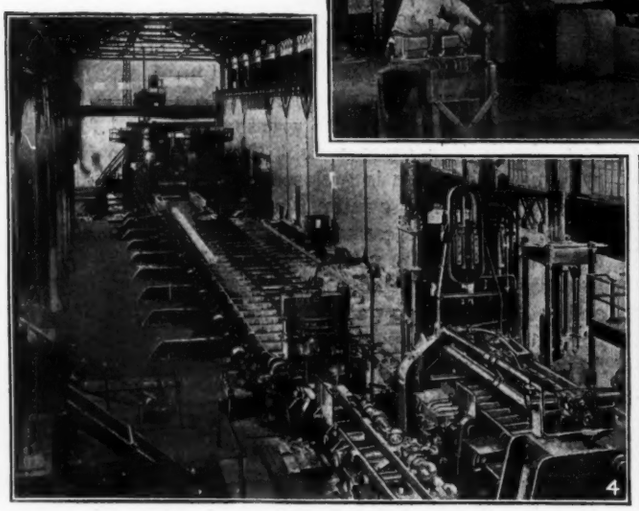
In operating the two-high mills, the steel is put through the rolls in one direction only, the return being over the top of the upper roll. After each passage the rolls are adjusted closer and the sheets are passed through them until the desired thickness is obtained. With a three-high stand the metal is rolled in both directions in its passage through the stand. On the forward pass the piece passes between the bottom and the center roll, and on the return pass the piece passes between the center and the top roll.

The view shown in Fig. 7 is of a complete sheet mill at the main plant of the Youngstown Sheet and Tube Co. The engine is a twin tandem-compound Corliss with a 84 and 60 x 60-in. cylinder and is rated at 2,000 hp. at 30 r.p.m. In this instance the engine shaft is coupled to the mill stand, there being no reduction of speed between the engine and the rolls, as is generally the case. The engine is placed in the center of the mill and drives a train from each end of the crankshaft. The method of roll adjustment is shown on the nearest stand. As the sheet comes to the rolls from the far side, it slides out on the rest piece and the bar at the back of the stand assists the operator to pass the sheet back over the top of the roll. The heating furnaces are shown at the extreme left, and the squaring shears at the extreme right together with several sets of rolls. The pile of sheet next to the engine partition indicates the kind of work produced. A front view of a complete plate mill is shown in Fig. 6. The arrangement is similar to that shown in Fig. 7, excepting that the stands are placed farther apart. In the foreground is a lever type of shear, the gearing of which is inclosed, and the location of the engine driving the stands is shown by the flywheel and its position between the stands. The heating furnaces are at the extreme right, the weighted door-lifting levers being shown.

When the rolls are to be changed on this type of mill, a traveling crane is moved in place and a tackle is attached to the two lugs that are formed at each side of the stand casting. It is then lifted out of the way sidewise, the rolls lifted out by the same crane, and the new ones are put in position when the stand is replaced.

If one wishes to see metal pass through a mill at extremely high rate of speed the continuous wire mill is the place to see it. A wire is produced from a heated





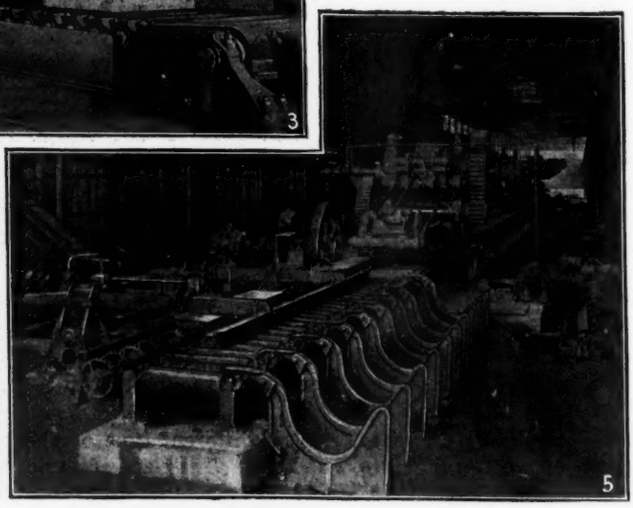


FIG. 3. A 3,600-TON CAPACITY STEAM-HYDRAULIC SHEAR AND BILLET SHEAR IN FOREGROUND. FIG. 4. A 44-IN. REVERSING MILL WITH SLAB SHEAR FIG. 5. MOTOR-DRIVEN BLOOM SHEAR

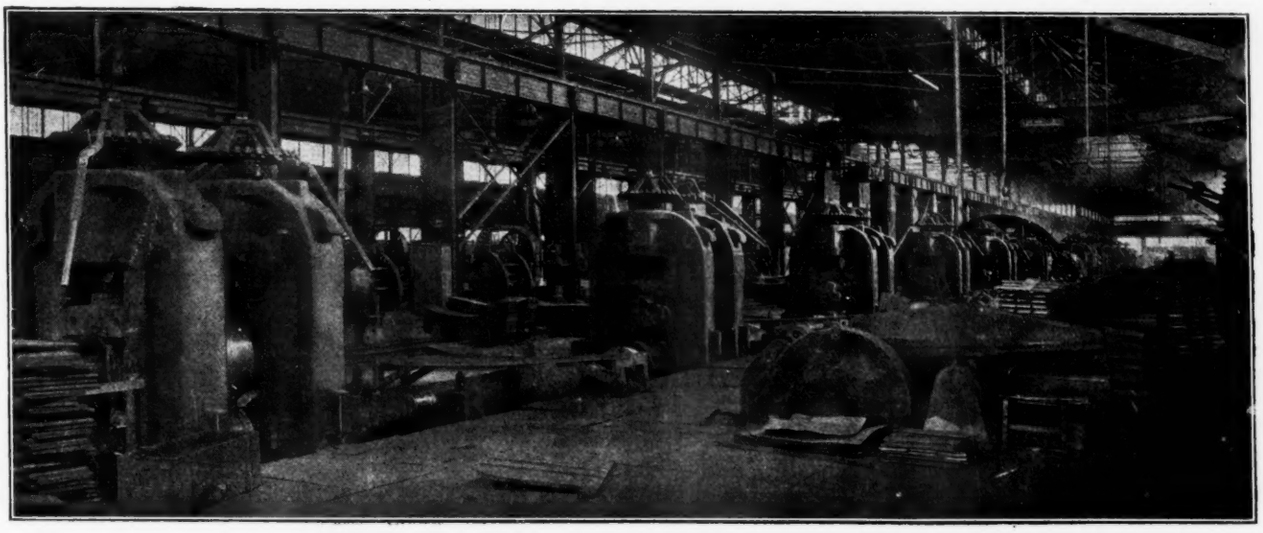


FIG. 6. A COMPLETE PLATE MILL. IT IS SIMILAR TO A SHEET MILL INSTALLATION

billet. In this mill the billet is sent from the heating furnace into the roughing mill rolls and passes automatically through the mill until it is wound on reels ready for tying up for delivery. The speed of the wire at the reel is about 30 miles per hour. The furnace in which the billets are heated is gas-fired. It is built sloping and the billets are sent down in a single layer as fast as one is pushed out to the roughing mill. This is done by a pusher machine, which in some mills grabs the end of the billet and after forcing it out of the oven turns it one-quarter turn just as it enters the rolls, so as to knock off the scale. The billet comes out of the furnace through a small door and enters the first stand of rolls, which is placed quite close to the furnace.

The billets are about 25 or 30 ft. in length and about $1\frac{3}{4}$ in. square. After passing through a number of stands, the wire is reduced to the desired size. Owing to the elongation of the billet each succeeding stand of rolls revolves at an increased speed so as to allow no slack betwen the stands. It requires about one minute from the time the billet enters the roughing roll until it is rolled up. By the time the last end of the billet has left the furnace, more than 50 per cent of the rod is wound up into a coil containing 2,000 or 3,000 ft. of wire, all depending on the size.

On leaving the roughing rolls the leading end of the billet passes through a pair of flying shears, which cut off a piece a few inches in length, the object being to get a clean end in order to permit of the correct entry of the work between the rolls of the succeeding intermediate trains. The flying shears are an interesting mechanical device consisting of a pair of blades which, during the act of closing, are free to travel with the moving wire until it is severed. After leaving the intermediate train, the work passes into the rolls of the finishing train, which may be driven separately from the roughing and intermediate trains, so that the rod will not be overfed between the intermediate and

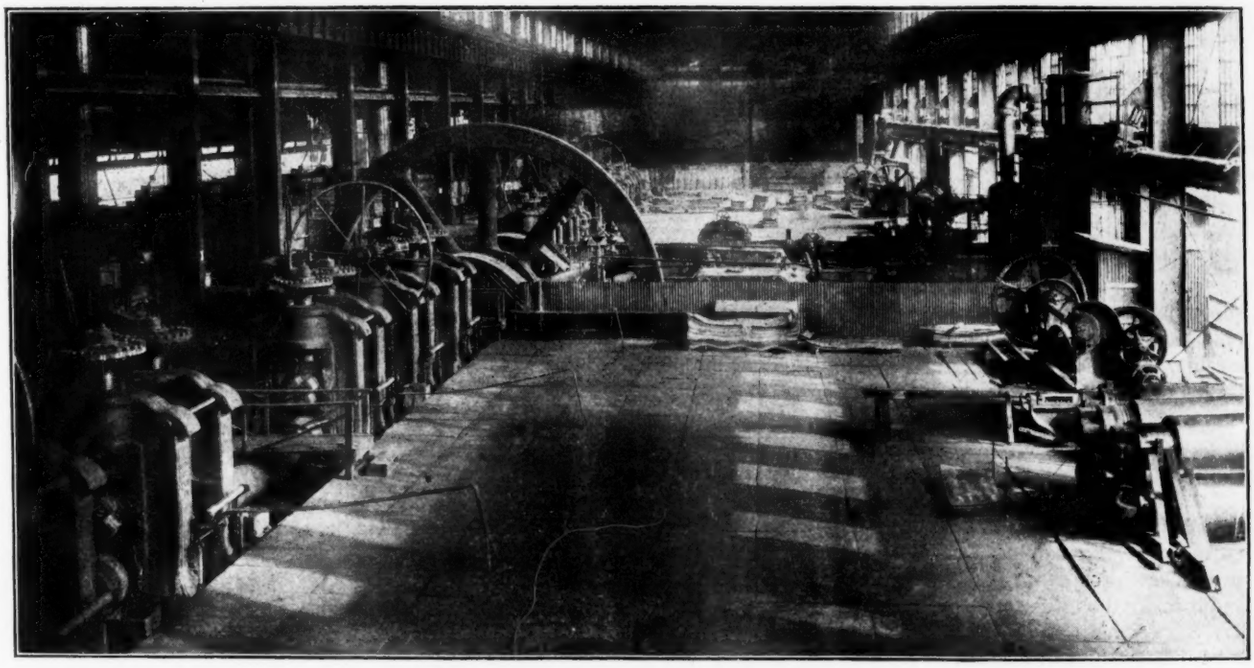


FIG. 7. A COMPLETE SHEET MILL. ENGINE PLACED CENTRAL BETWEEN STANDS

finishing rolls, which can occur, due to uneven wear in the roll grooves or because of a lack of synchronization of the engines. On the other hand, a difference in engine speed would be just as likely to develop a tension in the bar as to create a sag.

Uneven wear may be expected to occur, because the rolls of the intermediate train run at a considerably faster speed than the rolls of the roughing train. At the finishing train the wear in the grooves is more rapid

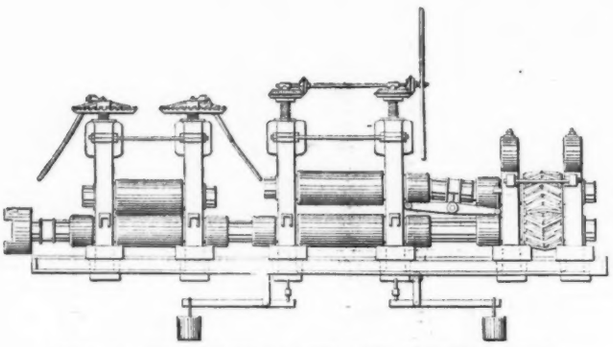


FIG. 8. TWO-HIGH PLATE AND JOBBING MILL

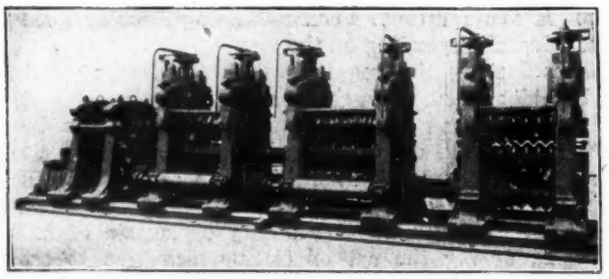


FIG. 9. THREE-HIGH BAR MILL

than in the rolls of the roughing train, and in order to reduce labor and delays involved in frequent replacing of the rolls, the rolls are cut with a number of grooves, all grooves being of the same section. Some mills, however, are made so that with any alternation in the size of the wire, the rolls would have to be changed.

(The next article will be devoted to electrical driving apparatus.)

Supporting Conduit Risers

By Roy J. Turner

The method shown in the accompanying illustrations has proved to be satisfactory and economical for holding the wires in a vertical conduit run so as to satisfy the National Electrical Code requirements. To apply this method, the back of the junction box must be of steel sufficiently heavy to "take" safely a machine-screw thread *M*, Fig. 1. Then the conductors can be gripped in porcelain cleats *A*, *B*, *C* and *D*. A piece of flat strap iron with a hole in each end is placed between the outer cleat and the machine-screw head. This distributes the strain and thereby prevents cracking of the porcelain. To support the conduits themselves, their ends should be threaded for some distance, as shown at *L* (Fig. 1) and a locknut run down on them. In fact, in some cities the inspection bureau requires two locknuts on every conduit that enters a steel box. In such cities a bushing and a locknut on the conduit *N*, Fig 1, are deemed insufficient. To economize space within the anchor box, it is often desirable to stagger the cleats, as exhibited at *C* and *D*. A heavy angle *S* should be provided to support the vertical weight of the box and the conductors in conduit which it supports. Angle S_T is also usually

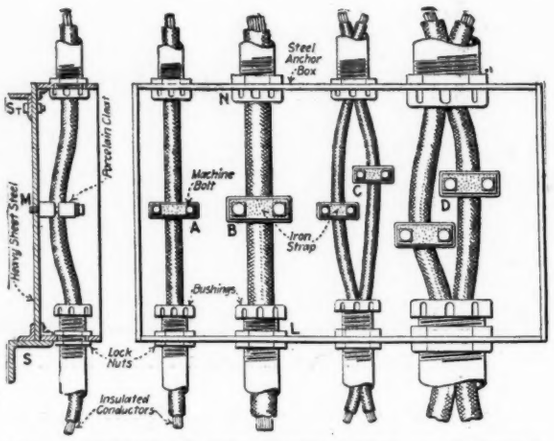


FIG. 1. SUPPORTS FOR CONDUCTORS IN VERTICAL CONDUIT RUNS

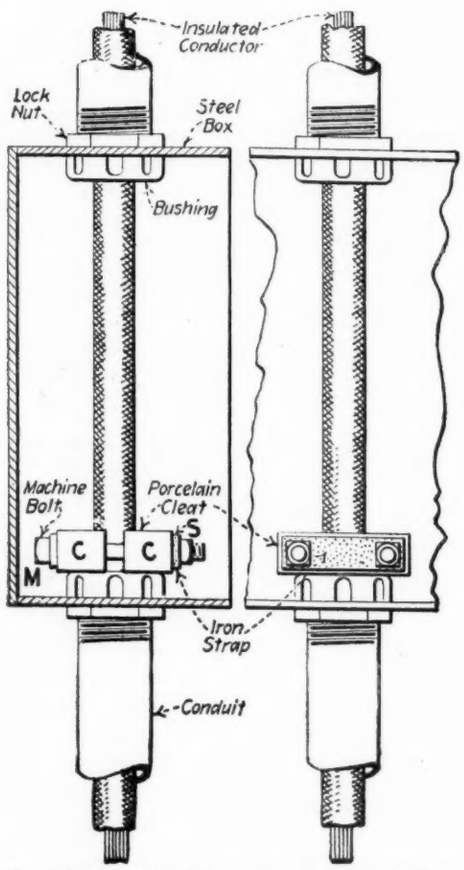


FIG. 2. CONDUCTORS IN A VERTICAL CONDUIT RUN SUPPORTED WITH A PORCELAIN CLEAT CLAMP

located at the top of the box, and the box is bolted to it. The arrangement given in Fig. 2 has also been applied successfully and is quite satisfactory for the smaller conductors. With this a cleat is bolted tightly around the conductor. This cleat rests on the bushing in the bottom of the box. Thus it prevents the conductor from moving vertically downward.

How To Calculate a New Winding for an Induction-Motor Stator Core

By A. M. DUDLEY
Designing Engineer, Westinghouse Electric and Manufacturing Company

The six factors that require consideration in figuring a new winding for an induction motor to operate under new conditions of speed, horsepower, voltage, phase or frequency are enumerated, then a problem is worked out to show how each is determined. No attempt is made to consider all the items that would be investigated by the designing engineer in working up a new design, but only those points that may be considered fundamental are treated of. However, the treatment is such as will give a winding that will be satisfactorily operative in a high percentage of cases.

THERE have appeared in *Power* at intervals for the last three years articles on "Reconnecting the Windings of Induction Motors" so that they might be operated under conditions differing from those for which they were originally designed. The author feels that this series is not quite complete until he has given some idea of how a winding may be figured for a given core without reference to any winding that might previously have been on the core. Obviously, in an article with the limited space assigned to this one, there cannot be attempted a complete treatise on the design of induction motors with detailed methods of calculation which will make him who reads a finished designer. In this discussion no reference will be made to all the points considered by the designing engineer, but only those factors will be covered in detail which it is felt are the most vital, and these will be handled in as elementary a manner as possible.

Performance of an Induction Motor

The performance of an induction motor is made up of a number of different factors. It must be able to start its load without drawing from the supply circuit an abnormal current, with a reasonable temperature rise and power factor. It must have a good efficiency and have as much mechanical clearance as possible between the stationary and rotating members so as to increase the life of the bearings. It must have a momentary overload capacity of from one and one-half to two times normal full-load torque without "pulling out" or stalling. Some of these characteristics may be favored at the expense of others; for example, it is possible to get a high power factor at the expense of having a very small clearance between stator and rotor, or it is possible to have a high efficiency at a cost of low starting torque and high starting current.

It is understood that all these characteristics are affected in various ways by the different features of the design, that is to say by the axial length of the iron core as compared to the rotor diameter, or by the number of slots or the kind and thickness of the laminated steel used and matters of this kind; but the thing that has the greatest effect and can most easily be modified is the number of turns in the stator or primary winding. In figuring this detail, which is of prime importance, it is therefore good practice to have at all times a mental picture of what happens to each characteristic when the cross-section of the conductors or the number of turns in the primary winding is changed. In order to summarize this quickly, the various characteristics are listed in order and considered separately. The main considerations in the operation of any induction motor are: Starting torque, starting current, air gap or clearance, power factor, efficiency, heating, maximum torque, or pull out, noise, and mechanical vibration.

If there were two motors that were exact duplicates in material and all mechanical dimensions excepting that one motor had more turns in the winding than the other, when comparing the characteristics just named, the motor having the most turns would have a lower starting torque and a lower starting current. It would probably have a higher power factor. It might have a higher or a lower efficiency for the reason that the copper loss would be higher and the iron loss lower, and whichever one preponderated would determine whether

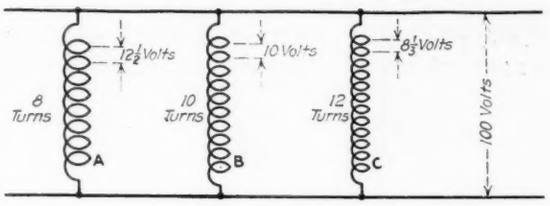


FIG. 1. THREE CIRCUITS IN PARALLEL

the efficiency was higher or lower; in other words, whether the copper loss increased faster than the iron loss decreased, and vice versa. Similarly, the heating would be more or less, depending on the sum of the losses. In general this motor would be a little quieter and have less tendency toward mechanical vibration.

On the other hand, considering the motor with the fewer number of turns, it will have relatively, a higher starting torque and a higher starting current. It will have a higher or lower efficiency depending on the proportion of iron to copper loss, as explained in the preceding paragraph; similarly, the heating will vary with the amount of total losses. This motor would have a tendency to be noiser and have more mechanical vibration.

It will be noticed that these changes are the same as would occur if the voltage were raised or lowered on any motor. Increasing the number of turns in a winding has the same effect as lowering the voltage, and decreasing the number of turns has the same effect as raising the voltage on the winding. This can be seen from Fig. 1, where three windings are shown in parallel across 100 volts. Winding *A* has 8 turns in series, and there are 12½ volts effective on each turn. Winding *B* has 10 turns, and there are 10 volts effective on each turn; similarly, winding *C* has 12 turns, and the effective voltage on each turn is 8⅓ volts. Since the per-

formance of the motor as regards torque and other characteristics is proportional to the voltage per turn in the winding, if we consider winding B as the normal winding for 100 volts, the A winding on 100 volts would operate and give the same result as the B winding if there were 125 volts applied to B. Similarly, the C winding on 100 volts would operate and give the same result as would the B winding if B had 83⅓ volts applied

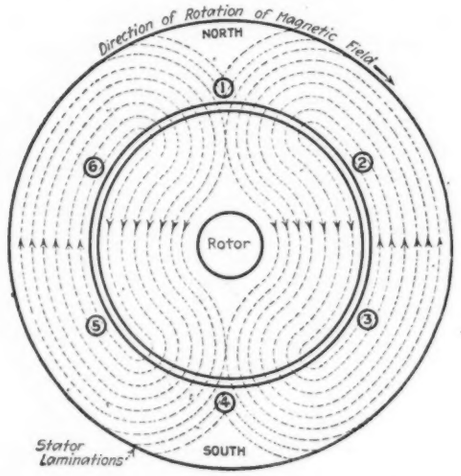


FIG. 2. FLUX DISTRIBUTION IN A TWO-POLE INDUCTION MOTOR

to it. Another vital consideration is the cross-section of the conductors used in the winding, necessary to carry the amperes required to develop the desired horsepower. There are in all 19 points that have to be considered by the designing engineer in making the complete design of an induction motor.

Since the consideration for the moment assumes an old core that already exists, many of these factors are already determined and some can be assumed. The facts that require checking in determining a new winding for new conditions of speed or horsepower or voltage or phase or frequency, and which may be considered as fundamental are:

1. Is the core large enough to wind for the horsepower and speed that are desired?
2. Is there cross-section of iron enough below the slots to carry the magnetic field that is needed in the air gap to do the work desired?
3. How many turns are required in the stator winding?
4. What should be the cross-section or size of the wire or conductor used in the stator winding?
5. What should be the cross-section of the bars in the rotor, and what should be the cross-section of the resistance rings at the ends of the rotor bars, assuming a squirrel-cage rotor winding?
6. Will the rotor diameter permit operating at the proposed r.p.m.?

These are a comparatively few questions that can be readily answered and broad general limits laid down against which the individual case can be checked. This will assume some points, but in general if the winding falls within these limits the motor will be sufficiently operative to fill the immediate requirement.

Proceeding at once to the determination of these quantities, (1) is answered by checking the so-called "output coefficient," that is to say, the horsepower of which a given core is capable at a given r.p.m. This may be expressed by the formula,

$$Hp. = K \times D^2 \times L \times r.p.m.$$

where K is the so-called "output coefficient," which varies somewhat with the size and speed of the motor and the operating voltage; D the diameter of the stator bore in inches; L the axial length of the laminated iron core in inches measured parallel to the shaft; and $r.p.m.$ the revolutions per minute.

Suitable values for the output coefficient may be found in several textbooks, but the table given in Sec. 7, par. 246, of the fourth edition of the "Standard Handbook for Electrical Engineers," is reproduced herewith.

Pole Pitch in Inches	Values of Output Coefficient K When Output Is Expressed in Horsepower, Linear Dimensions in Inches and Speed in Revolutions per Min. 4 Poles	8 Poles	12 Poles	16 Poles	20 Poles	24 Poles
5	.....	0.000025	0.0000265	0.0000263	0.0000254	0.0000246
7	0.0000222	0.0000329	0.0000331	0.0000331	0.0000331	0.0000331
10	0.0000336	0.000039	0.0000394	0.0000394	0.0000394	0.0000394
12	0.0000392	0.0000436	0.0000438	0.0000440	0.0000443	0.0000443
16	0.0000434	0.0000482	0.0000484	0.0000486	.....	.....
20	0.0000454	0.0000505	.....	.....	.....	.....

The following example is given to illustrate the use of this table. A stator core having a bore of 17 in. and an axial length of 6 in. was brought into a repair shop and a request made to put in a winding for 50 hp. to operate at about 730 r.p.m. on 25 cycles. To determine whether this was physically possible, the following cal-

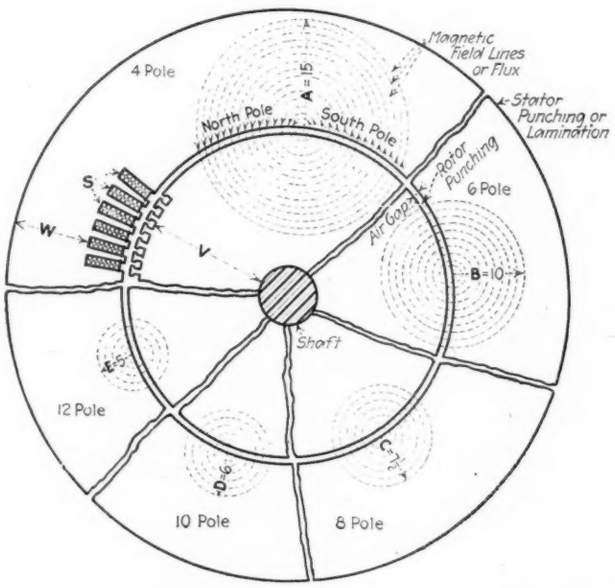


FIG. 3. CORE SECTION, SHOWING EFFECT ON MAGNETIC FIELD BY CHANGING NUMBER OF POLES

culation was made. The number of poles necessary to give the required speed is found by the expression,

$$Poles = \frac{Cycles \times 120}{r.p.m.}, \text{ in this case} = \frac{25 \times 120}{730} = 4$$

$$Pole\ pitch\ in\ inches = \frac{diameter \times 3.14}{number\ of\ poles} = \frac{17 \times 3.14}{4} = 13.4$$

The nearest figure to this in the table is 12 in. and opposite 12 in. under 4 poles is the figure 0.0000392. Then the horsepower that this core will develop at 730 r.p.m. is $0.0000392 \times 17^2 \times 6 \times 730 = 49.6$. Hence, the conclusion is reached that this core would wind satisfactorily for 50 hp at 730 r.p.m., since the output

coefficient for 13.4 in. would be a little greater than for 12 in. in the table which was used in the trial calculation.

The second question, as to whether there is sufficient cross-section of iron in the core between the bottom of the slots and the outside periphery, can be determined by figuring the actual amount of magnetic flux per pole that must be set up to do the required work. This can

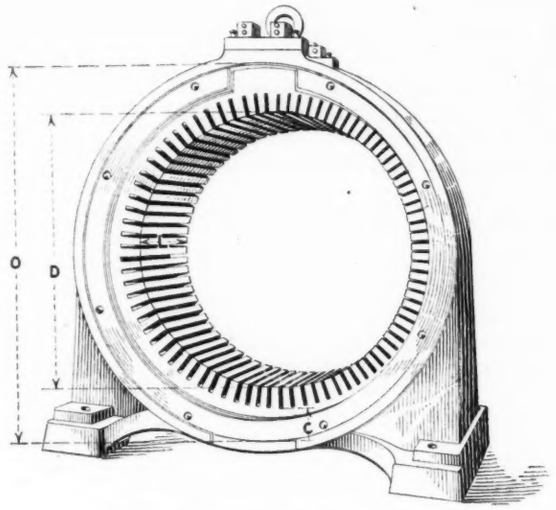


FIG. 4. STATOR CORE IN FRAME

be readily understood by a reference to Figs. 2 and 3, which illustrate the manner in which the magnetic flux is divided into as many groups or circuits as the motor has poles. In passing from the stator to the rotor through the teeth, then behind the rotor slots and back to the stator and again behind the stator slots to the starting point, it will be noted that there must be enough iron behind the slots to carry the flux or the motor will overheat. Referring to Fig. 3, it is evident that the more poles the motor has, the less iron it requires in the core behind the slots of both stator and rotor. Therefore, the correct way to determine this point is to figure the amount of magnetic flux per pole and figure the cross-section of the core behind the slots and see that there are not more than 80,000 to 100,000 magnetic lines per square inch and if so, and other conditions are proper, the core should be satisfactory for the assumed conditions of the winding.

Peculiar Design Problem

Here we are confronted with a peculiar problem which often faces the designer, which is, that he must know part of his answer before he can solve the problem and find the rest of it. In other words, the amount of magnetic flux in the core will depend on the number of turns of wire in the coils, and the problem which he is trying to solve is how many turns should be put in the coils. So it is apparent that he must guess the number of turns required and find out if the amount of magnetic flux is reasonable, or else he must figure how much flux can be carried in the core he is using and from that figure check back and see how many turns are required in the winding to give this magnetic result. When the number of turns is settled and the cross-section of the copper is figured for the desired horsepower and voltage, there is at once a question whether the slots will accommodate that many conductors of that cross-section after taking room enough to allow for the insulation required on the coil at that particular voltage. If the result is unfavorable and the copper so figured will not go in the slot at all, it means that the motor is not good for that much horsepower and the desired rating will have to be reduced. The number of turns cannot readily be reduced as that would mean more magnetic flux, and the core back of the slots is already figured for 80,000 to 100,000 lines per square inch, which is all it will stand. The reason why the number of conductors and the magnetic flux are tied in together in this way is because the conductors which are in series, when cut by the rotating magnetic field, must generate or produce practically line voltage. This fact has been referred to many times in previous articles.

The formula for the field flux per pole or per magnetic circuit is

$$\textit{Flux per pole} = \frac{45{,}000{,}000 \times \textit{Volts per phase}}{\textit{cycles} \times \textit{conductors per phase} \times K_1 \times K_2}$$

where

Volts per phase = Line volts in the case of a two-phase winding or a delta-connected three-phase winding, and
= Line volts ÷ 1.732 in the case of a star-connected three-phase winding;

Conductors per phase = Number of wires per slot which are in series × number of slots ÷ number of phases;

K_1 = A so-called "distribution factor" and is 0.905 for two-phase and 0.955 for three-phase;

K_2 = The so-called "chord factor" and depends on the pitch or throw of the coil. Its technical value is the sine of one-half of the electrical angle spanned by the coil.

A practical method of getting this factor, which is close enough for general purposes, is to use the expression

$$\textit{Chord factor} = K_2 = \sqrt{\frac{(\textit{No. slots per pole})^2 - 2(\textit{No. slots dropped})^2}{(\textit{No slots per pole})^2}}$$

or taking a concrete example, suppose there is a 72-slot motor wound for six poles and having a coil throw of 1 and 8, what is the chord factor, or K_2, which is under discussion? Since there are 72 slots and six poles there are 12 slots per pole and full pitch would be slots 1 and 13. Winding 1 and 8, drops 5 slots and thus our formula becomes

$$\sqrt{\frac{12^2 - 2(5)^2}{12^2}} = \sqrt{\frac{144 - 50}{144}} = \sqrt{\frac{94}{144}} = 0.80$$

To illustrate how this flux formula is applied, assume a core having dimensions as shown in Fig. 4. which it is desired to wind for 50 hp. 25 cycles three-phase four poles, 440 volts and 730 r.p.m. full-load speed. The outside diameter O of the stator lamina-

tions equals 25½ in., inside bore D of the stator laminations equals 17 in. The axial length of the core L equals 6¾ in., but it contains two ventilating ducts each ⅜ in. wide, so that the net iron core length equals 6 in. The primary slots are 1.7 in. deep, so that the dimension C, or the radial depth of the laminations below the slots, equals $(25\frac{1}{2} - 17) \div 2 - 1.7 = 2.55$ in., and the actual cross-section of the core below slots through which all of the flux per pole must pass is equal to $C \times L$, or in this case $2.55 \times 6 = 15.3$ sq.in. A reference to Fig. 2 of this article indicates that when the flux per pole passes from the rotor into the stator, it divides and half goes one way and half the other way. Hence, in the present case the total available cross-section of iron to carry the flux per pole is not 15.3 sq.in., but twice that, or 30.6 sq.in. As previously stated, 80,000 lines per square inch is a permissible density, so that a total flux per pole of $30.6 \times 80{,}000$ can be used, or 2,448,000 lines. The only other factor missing from the flux per pole formula which is necessary to give at once the total number of conductors per phase is the chord factor. This depends upon the slots in which the two sides of any coil are placed. In the core that is under consideration there are 48 slots, and since a 4-pole winding is under calculation, the full pitch for the winding would be slots 1 and 13. Full pitch is too long mechanically, and some space endwise can be saved and some copper as well by chording it a few slots, so for illustration it is assumed that the coils lie in slots 1 and 10. Using the approximate formula given for chord factor above, this factor becomes

$$\sqrt{\frac{12^2 - 2(3)^2}{12^2}} = \sqrt{\frac{144 - 18}{144}} = \sqrt{0.875} = 0.93$$

Expressing the flux per pole formula in terms of conductors per phase, this expression follows:

$$\textit{Conductors per phase} = \frac{45{,}000{,}000 \times \textit{volts per phase}}{\textit{cycles} \times \textit{flux per pole} \times K_1 \times K_2}$$

Remembering that the distribution factor for three-phase equals 0.955 and substituting the values calculated, and assuming a delta-connected winding,

$$\textit{Conductors per phase} = \frac{45{,}000{,}000 \times 440}{25 \times 2{,}448{,}000 \times 0.955 \times 0.93} = 362$$

Since there are three phases, there will be required a total number of conductors $3 \times 362 = 1{,}086$; and since there are 48 slots, there will be $1{,}086 \div 48 = 22.6$ conductors per slot. What a designer would do in this case would be either to wind 22 conductors per slot and throw the coil 1 and 11 instead of 1 and 10 or else to wind it 24 per slot and throw the coil 1 and 9, either of which would be a good winding without a great deal of difference between the two.

There are two coils per slot and hence with 22 wires per slot there would be 11 wires in each coil. As the wires are arranged in two or three layers, 11 would not be exactly divisible by either 2 or 3, hence, in the case of a two-layer coil there would be one layer of 5 wires and one layer of 6 wires side by side, or in the case of a three-layer coil there would be two layers of 4 wires each and one layer of 3 wires. Either of these arrangements would be wasteful of space, and hence it would be preferable to have 12 wires per coil, which is evenly divisible by either 2 or 3. If the coil is wound in slots 1 and 11, the chord factor is 0.97, and if it is wound in 1 and 9 the chord factor is 0.866. Hence, the real, effective number of wires in one case is $22 \times 0.97 = 21.3$ and in the other case is $24 \times 0.866 = 20.78$, which would give very close to the same result so far as torques are concerned.

In this calculation it was noted that the figure 440 was used for the voltage. This assumed a series-delta connection. If, for example, it had been desired to connect the winding in two parallel delta for the same voltage, there would have been required twice as many conductors per phase and each conductor would have had one-half the cross-section, since there would be two paths in parallel for the current instead of one in series. Similarly, if the winding was to have been connected in series star instead of series delta, the voltage used in the equation would have been $440 \div 1.73 = 254$ instead of 440. Hence, in the result the conductors required per phase would have been $\frac{362}{1.73} = 209$ instead of 362. It is well to remember the fact that with a star connection only about one-half as many turns are required in series as with a delta connection. It sometimes makes an easier coil to wind and a coil that is mechanically stiffer and stronger, if less turns of a

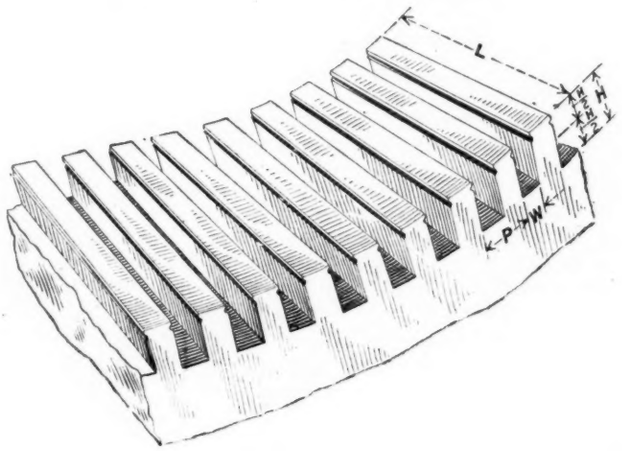


FIG. 5. SECTION OF STATOR CORE

larger-sized wire can be used. This is one of the principal reasons why a star connection is used much more frequently than a delta connection.

The foregoing calculation concerned itself only with the density of the magnetic flux in the stator core behind the slots and was checked first to make sure the required field had room to get through the core. However, before accepting this figure the teeth should be checked also to see how hard they are working. The diameter of the stator bore of the core under calculation is 17 in. The depth of the slots is 1.7 in., therefore the diameter to the middle of the slot is 18.7 in. and the slot pitch at this point or the dimension P from Fig. 5, equals $\frac{18.7 \times 3.14}{48} = 1.22$ in. The slot width $W = 0.65$ in., hence the tooth width $P - W = 1.22 - 0.65 = 0.57$ in., and since the net core length $L = 6$ in., the cross-section of one tooth at its mid-section is $6 \times 0.57 = 3.42$ sq.in. There are 48 teeth total and 4 poles, hence there are 12 teeth per pole through which the magnetic flux of one pole may pass. Therefore, the total iron cross-section of 12 teeth $= 12 \times 3.42 = 41.04$ sq.in. It was calculated in the fore-

going that there were 2,448,000 magnetic lines per pole and it would seem that all that was necessary to check the tooth density would be to divide this figure by 41.04. This is not the case as in the core, for the reason that all the teeth do not carry the flux equally, but those in the center of a pole at a given section carry a maximum and those halfway between poles carry nothing, so that in order to take care of the maximum, the foregoing result is divided by 0.636. Hence, in the problem in hand, the maximum density in the teeth is $\frac{2,448,000}{41.04 \times 0.636} = 94,000$ lines per square inch. As a matter of fact it is actually about 96,000 lines, since the 2,448,000 was figured with 362 conductors per phase and a throw of one and ten, whereas there are now $24 \times 48 \div 3 = 384$ conductors per phase, but the throw is only one and nine, and substituting back in the original flux equation,

$$\textit{Flux per pole} = \frac{45,000,000 \times 440}{25 \times 384 \times 0.955 \times 0.866} = 2,480,000 \text{ lines.}$$

This value (96,000 for density in the teeth) is perfectly permissible. It should not be allowed to exceed say 130,000 for 25-cycle machines, nor about 110,000 for 60-cycle machines.

Cross-Section of Conductors

Having determined the number of conductors required in the slot—that is, 24—the next step is to figure the necessary size of the conductor or cross-section and see if the coils will go in the slot after being properly insulated. In order to figure this, it is necessary to know what the full-load current of the motor will be. The formula for finding the full-load current of a two-phase motor is,

$$\textit{Full load current per lead} = \frac{\textit{Horsepower} \times 746}{2 \times \textit{volts per phase} \times \textit{efficiency} \times \textit{power factor}}$$

where the efficiency and the power factor are the full-load values and are expressed in hundredths, that is with a decimal point in front of each. For example, 90 per cent efficiency is written 0.90 and 85 per cent power factor is written 0.85, etc. For a three-phase motor the formula changes to,

$$\textit{Full load current per lead} = \frac{\textit{Horsepower} \times 746}{1.73 \times \textit{volts per phase} \times \textit{efficiency} \times \textit{power factor}}$$

which it will be noted is similar to the two-phase formula except 1.73 is used in the denominator instead of 2. One thing must be especially noted about the three-phase motor, and that is, the full-load current so found is the current in the outside motor lead or the current drawn from the line. If the motor is star connected inside, this same current flows in the motor winding itself and hence in the conductors in the slots, unless the winding is in two or more parallels, in which case, of course, the lead or line current splits up into as many parts as there are parallel paths. On the other hand, if the windings inside the motor are delta connected, as they are in the case we are considering, the current in the windings will be less than the current coming in the lead as figured in the foregoing and it is necessary to divide by 1.73 a second time to find what current must be provided for in the coils themselves.

Preparing to apply the foregoing formula, at once the problem arises, What is the full-load efficiency and the full-load power factor of the motor for which this winding is being figured? Of course there is a wide variation in these figures between small and large motors, and between high and low speeds, and between 25 and 60 cycles. The handiest approximation the author has ever used and one that has given good results is to assume that a three-phase 550-volt motor draws from the line in each lead just about one ampere per horsepower. This is very closely true in most lines of commercial motors over a wide range of sizes and speeds. Then if the motor in question is not three-phase or if it is not 550 volts, the current can readily be changed to other voltages. For example, assume a 40-hp. motor. Then at 550 volts three-phase it follows that its full-load current per lead is 40 amperes, at 440 volts its full-load current would be $\frac{550}{440} \times 40 = 50$ amperes, at 220 volts it would be $\frac{550}{220} \times 40 = 100$ amperes, at 110 volts it would be $\frac{550}{110} \times 40 = 200$ amperes, and so on. Similarly, to convert to two-phase, multiply these values by $\frac{1.73}{2.00} = 0.86$, because the current per terminal of any two-phase motor is always 0.86 times that of a corresponding three-phase.

Referring again to the formula for the full-load current of a three-phase motor, to give one ampere per horsepower at 550 volts would mean that the product of the efficiency and power factor would be 0.785. This might be assumed to be 89 per cent efficiency and 88 per cent power factor or any other combination whose product gave 0.785. At all events this is an average value and sufficiently near correct for the present purpose.

Since the present calculation assumes a 50-hp. three-phase 440-volt rating, it may be assumed that the full-load current per lead is $\frac{50 \times 550}{440} = 62.5$ amperes. Since the winding is to be delta connected, the current in the coils themselves will be $\frac{62.5}{1.73} = 36.1$ amperes.

Circular Mils per Ampere

There is no fixed rule that can be followed for the cross-section of copper required in the coil per ampere. It may be as low as 400 circ.mils in some cases and may have to be as high as 1,000 circ.mils in others. Slow-speed motors and higher voltages (where there is more insulation to pass the heat through) require larger copper than do higher speeds and lower voltages. In the present case and in most average cases a figure of 750 circ.mils can be used. For the present case, then, the circ.mils required would be $36.1 \times 750 = 27,075$. Looking in a wire table, the nearest size to this is No. 6 B. & S. round wire, which shows 26,250 circ.mils, which is near enough. The problem now is, Will 24 No. 6 wires go in a slot 0.65 in. wide by 1.70 in. deep and allow for the retaining wedge at the top and the proper insulation for 440 volts? To answer this it is necessary to know something about insulation requirements. As there are commonly only two voltage classes met with, it can be stated that voltages up to and including 550 volts

will require a space in the width of the slot of about 0.1 in. and in the depth of the slot of about 0.15 in. and voltages above 550 up to and including 2,200 will require about 0.16 in. in width and 0.26 in. in depth. These figures in depth do not include any retaining wedges, but must be allowed in addition to the wires between the bottom of the wedge and the bottom of the slot. In the case just being figured, the wires will evidently go in better 3 x 8 than any other way. The diameter of No. 6 round wire over double cotton covering is 0.178 in. Three wires in width would be $3 \times 0.178 = 0.534$ in.; adding 0.1 in. for insulation gives $0.534 + 0.1 = 0.634$ in., which goes very well in the width of the slot, which is 0.65 in. In depth 8 wires would require $8 \times 0.178 = 1.424$ in. The allowance for insulation is 0.15 in., and the usual coil retaining wedge requires 0.125 in., so that the total required depth will be $1.424 + 0.150 + 0.125 = 1.699$ in., which just exactly fills the available depth. It should be understood that the 24 wires are not 3 x 8 in one coil but 3 x 4 in each coil and two coils in the slot according to the usual practice.

If the wires had not fitted in the slot as shown it would have been necessary to choose a wire small enough to go in the space and then by trial after the winding was complete find out how many horsepower the winding would carry without overheating. If it were not possible to get 50 hp., it would probably develop 45 hp. without trouble if the output coefficient checked to 50 as shown in the beginning of this article.

Calculations for Rotor Winding

With regard to the rotor winding, if it is of the wound-rotor type the number of wires per slot can be made any number that is convenient provided the total weight of copper in the rotor winding is made approximately 80 per cent to 85 per cent of that in the complete stator winding.

If a phase-wound, the coils must of course be connected for the same number of poles as the stator. If there should be an old winding on the rotor for a different number of poles, it may be possible to reconnect it for the number desired; but as rotor windings are nearly always of the "wave" type or something of the same order, it is usually impossible to reconnect for any other number of poles.

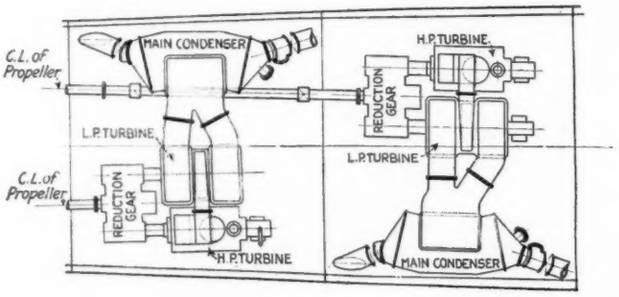
If the rotor winding is squirrel cage, the number of bars and their cross-section are probably fixed. The cross-section of the end rings, if of rolled or drawn copper, should be so chosen that the weight of bars plus rings is perhaps 75 per cent to 80 per cent of the total weight of the stator coils. If the rings are cast copper or cast brass, it should be remembered that a larger cross-section will be required, since the conductivity of the best cast copper is only 80 per cent to 85 per cent of the conductivity of rolled copper, and cast brass is as low as 18 per cent to 25 per cent of the conductivity of drawn or rolled copper. This would mean that a ring of cast brass would have to be 4 to 5 times the cross-section of the corresponding rolled copper ring to carry the same current. It should also be remembered that a two-pole motor would have proportionately the heaviest ring on the squirrel cage, a four-pole next, then a six and so on, and that when ten poles or twelve poles are reached the ring would probably be no larger in cross-section than would be required for mechanical strength and construction.

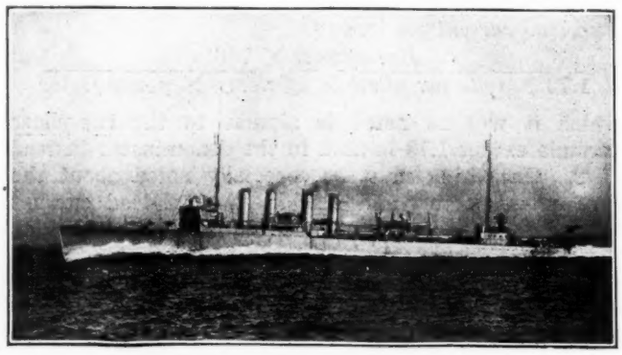
Such in its briefest form is the simplest calculation that can be made which it is safe to make in the hope of getting the desired results. It will be noticed that no attention has been paid to calculating the leakage reactance, the no-load current, the starting and maximum torques, the circle diagram nor any of the refinements that the designing engineer commonly employs; and yet if care is used in employing the checks that are made, the experimenter should be rewarded with reasonable results.

To sum up, the available core is first checked by the output coefficient to see if it will develop the horsepower at the desired speed. Next a check is made to see how much magnetic field can be handled in the core and teeth. Then the proper number of conductors is chosen to generate the line voltage when acted upon by the permissible magnetic field. These conductors are then made of the proper size to carry the working current and insulated for the working voltage and fitted in the slots. This is all that is attempted, and it is assumed that if these conditions are met, all the other conditions of operation will fall reasonably in line or can be adjusted after trial without too much change to meet the desired requirements. Naturally, such broad assumptions may not result in a design of finished nicety, but they may sometimes give quick results where results must be had quickly or not at all.

Swiftest Vessel in United States Navy

In her recent official trials the United States "Satterlee" broke all American speed records by steaming at a rate of 38.257 knots. The best previous record made by an American war vessel is 37.04 knots. The





THE DESTROYER SATTERLEE

"Satterlee" is driven by two 14,000-hp. Westinghouse compound turbines which developed 31,223 hp. and broke all power records for this class of vessel. The diagram shows the layout of the engine room and the location of the two turbines and condensers.

Refrigeration Study Course—XIII. Ammonia and Ammonia Piping

By H. J. Macintire

IN THE steam engine or turbine plant the quality of steam delivered to the engine is uniformly constant, as a rule. For instance, it may be wet, dry and saturated, or superheated. It may have a trace of air present, but this is almost negligible. In the boiler room, however, conditions are different. The feed water may be heavily acid or impregnated with carbonates, sulphates or other solids in solution. If exhaust steam is returned to the boiler from the hotwell or open heater, there may be considerable oil contamination, all of which tends to cause scale or corrosion of the tubes or plates.

Refrigerating systems have troubles somewhat of the order of these boiler difficulties, but in a different manner. The system may accumulate air, on account of repair work, or with the low side operating under a vacuum or by carelessness in the initial charge of the system. Then moisture may get into the expansion piping when blowing out the coils with steam to remove oil, or by being carried into the system by condensing on the piston rod. The oil, of course, gets into the coils by being carried out of the cylinder with the discharge gas. Let us see how these impurities affect operation and the production of refrigeration.

The Effect of Air

The effect of air in a steam condenser is to increase the back pressure, which decreases the economy of operation. Air or other inert gas in the ammonia system collects in the condenser, where it increases the head pressure over and above that which should exist due simply to its own vapor tension. The head pressure may be 10, 20, 50 or more pounds greater than it should be, and the horsepower required to produce a ton of refrigeration will be correspondingly increased.

In addition the air collects in the condenser, first forming an insulation film about the condenser pipes, Fig. 1, and then, as it accumulates, fills the condenser. It is a mistake to suppose that air or inert gas collects in any particular part of the condenser. All gases tend to diffuse and become uniformly mixed. The only way to separate the ammonia from the gas is to condense it. This is done partly in the process of purging when the cooling water is showered over the pipes while the compressor is not pumping on that particular stand; then the gas in the upper part of the condenser is allowed to bleed out, it being less rich in ammonia in the process.

The Effect of Water

Air in the system is thereby seen to affect the head pressure and therefore to increase the horsepower per ton, but the accumulation of water in the ammonia system has a worse effect: It may prevent obtaining the required temperature in the refrigerating coils. Moisture *will* get into the system in one way or another. If it gets in via the condenser, it mixes with the anhydrous ammonia in the receiver and finally passes through the expansion valve into the refrigerating coils. As the boiling pressure of the ammonia (the back pressure) is relatively high, there is an almost negligible tendency for the water in the coils to evaporate. It remains in the low side and forms first a strong aqua ammonia, and then (as the water increases) a less strong aqua.

Aqua causes the cooling coils to behave *dead*. The boiling action is decreased, or the temperature required cannot be obtained. To get the results desired, a lower suction pressure must be carried than would be required if the ammonia were free of water. The result of a lower suction pressure for ammonia compressors has already been given considerable emphasis, increasing, as it does, the horsepower per ton of refrigeration and

BOILING POINTS OF AMMONIA

Suction Pressure, Lb. Gage	Boiling Temperature Saturated Ammonia, Deg. F.	Boiling Temperature Ammonia—5 per Cent Moisture, Deg. F.	Boiling Temperature Ammonia—10 per Cent Moisture, Deg. F.	Boiling Temperature Ammonia—15 per Cent Moisture, Deg. F.
30	17.4	22	27	32
25	12.2	17	22	27
20	6.5	12	16	22
15	0.1	5	10	14
10	—7.2	—3	2	7
5	—15.9	—12	—7	—2

decreasing the capacity of the compressor. The effect may be noted in the table, which shows the boiling temperatures of aqua ammonia under various pressures.

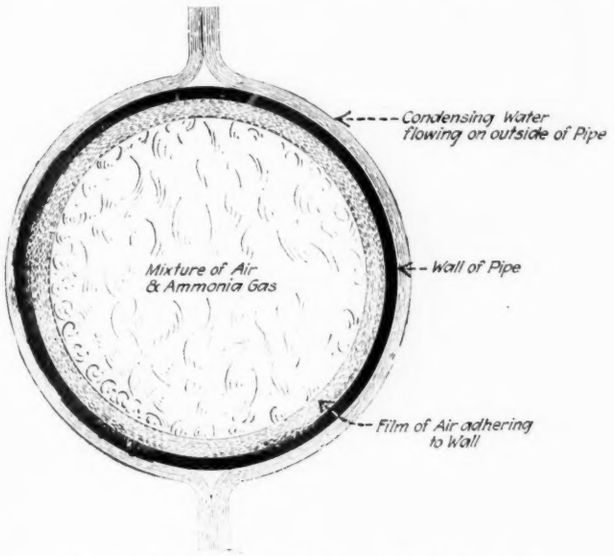


FIG. 1. SECTION OF CONDENSER COIL WHEN FUNCTIONING

For example, at 20 lb. gage pressure anhydrous ammonia will boil at 6.5 deg. F., but if 10 per cent water is present the temperature of boiling of the solution (at 20 lb.) will be 16 deg. F. Therefore (see table) it will require a suction pressure of 10 lb. with 15 per cent moisture to give the same boiling temperature as can be obtained at 20 lb. with anhydrous ammonia.

The Effect of Oil

No refrigerating system can be kept entirely free of oil. The vertical inclosed-type compressors are splash lubricated, and the horizontal high-speed machines must have copious amounts of oil or trouble will occur. Even the old style, slow-speed compressors carry over considerable oil, which is supposed to be caught by the oil separator. However, we all know that no separator can remove all the oil from the discharge gas. Some is volatilized and condensed with the ammonia in the con-

denser, and some is not caught by the separator. In fact, it is safe to assume that from 2 to 5 per cent of the oil will get into the condenser and ultimately collect in the low spots of the direct expansion piping. It may mix with impurities or dirt and form a thick mud, or it may solidify at the temperature carried in the system.

The net result of oil in the expansion piping is for reduced efficiency of coil surface. The oil or grease will form an insulating covering. As everyone knows, the refrigerating coils are the means only of heat exchange. The ammonia is evaporated by being in an *atmosphere* which is hotter than the boiling temperature of the ammonia at the *pressure* being maintained in the coils. Therefore, heat passes into the coils, and the ammonia is boiled away to make room for more liquid passing into the coils through the expansion (pressure-reducing) valve. In consequence of heat being used to boil the ammonia, the atmosphere or brine is cooled. We naturally desire to get as many heat units past the walls for every square foot of pipe surface as is possible under the circumstances, but an oil film $\frac{1}{100}$ in. thick is as bad as a boiler scale $\frac{1}{10}$, or a steel plate 10 in. thick.

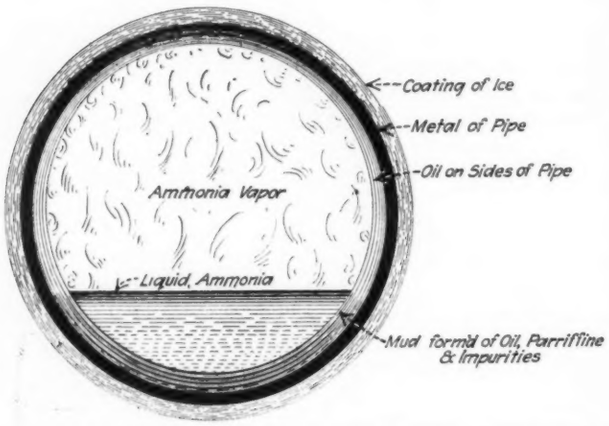


FIG. 2. SECTION OF COOLING COIL WHEN FUNCTIONING

Unlike steam surface condensers, which are usually of brass and some 0.05 in. thick, refrigerating piping is usually 1¼ or 2 in. normal diameter and the walls are usually extra heavy. The outside surface is frequently heavily coated with ice; the net result is a great reduction in the unit heat transference (see Fig. 2). If a pipe will not allow sufficient heat to transfer, then more surface will be required or a greater temperature difference will have to be carried. Either of these alternatives is commercially unbearable, and so the piping must be kept in as clean a condition as possible, just as in boiler and steam condenser practice.

The best possible arrangement of piping to keep the low side free of oil or water is to arrange all piping so that it will drain, and contain no pockets. At each low point install a trap which may be opened to the atmosphere or to a regenerator apparatus. Although semi-solid oil will still remain on the sides of the expansion piping, yet ease in cleaning is obtained and liquid impurities may be drained readily.

Direct-Expansion Piping

More trouble is encountered with the low side, perhaps, than with any other part of the system. The cause is mainly due to the fact that it is not generally clearly understood. And yet it certainly is not more difficult to understand than the steam boiler, the steam surface condenser, the closed feed-water heater or the economizer. Each of these devices is a heat-exchange apparatus, and the heat transfer is made possible by having *metal* contact with the two substances. But to transfer heat there must be a temperature *difference* on the two sides of the metal—a temperature difference in the two substances, the ammonia and brine or ammonia and atmosphere in the room to be cooled.

As has been pointed out before, the ammonia in the refrigerating coils must be maintained at the proper pressure for satisfactory service. Why does not a drum of ammonia provide refrigeration and become frosted with a thick layer of frost? Why does not the liquid receiver normally become frosted and tend to refrigerate the compressor room, also the liquid lines leading up to the expansion valves? Because the pressure in these pipes or drums is too great, and therefore the temperature corresponding (due to its saturation laws) is greater than or equal to the temperature of the air in the engine room or the atmosphere. To have an evaporation of the ammonia, its boiling temperature must be below that of the substance on the other side of its container. The heat must flow into the expansion coils from the outside. The point in question is brought out by every-day operation of the plant. If a sharp freezer and a cooler are on the same system and a pressure of 15 lb. gage is carried, the ammonia will become "lost" and the receiver will become empty. Investigation will show that the sharp freezer coils are flooded because the room was too cold to evaporate the ammonia and it accumulated in the coils. The remedy would be in reducing the back pressure to 10 lb. or 5 lb. gage, in which case the boiling temperature of the ammonia would drop to —7.2 deg. F. or —15.9 deg. F. and, as the sharp freezer is supposed to be kept at zero degrees, boiling action would be stimulated and refrigeration would be maintained. This whole process is expressed by the formula:

Refrigeration in B.t.u. = *area of pipe in sq.ft. times coefficient of heat transmission times temperature difference on the two sides of the pipe.*

which shows that no matter what area in square feet is available (it could be 10,000 sq.ft.) unless there is a temperature difference on the two sides of the pipe so that heat may flow from the air to the ammonia, there will be no refrigeration.

From the formula it would seem that to secure refrigeration in moderate amounts it is necessary to have either extensive piping or a large temperature difference. For example, a ton of refrigeration may be obtained by the following:

Sq.Ft.

A.... $400 \times 2 \times 15 = 12{,}000$ B.t.u. per hour

B.... $200 \times 2 \times 30 = 12{,}000$ B.t.u. per hour

where in each case the coefficient of heat transmission is taken as being equal to 2.0. In B only half the piping is needed as compared with A, but the temperature difference is twice as great, thereby requiring about 10 lb. suction as compared with a case using 20 lb. as A. Likewise, if 800 sq.ft. were used only 7½ deg. F. temperature difference would be required, and a higher suction pressure. The higher the suction pressure the greater the number of pounds of ammonia handled, and therefore the greater the efficiency of operation with respect to the power input.

Steam-Engine Operation and Maintenance—Loose Flywheels

By H. HAMKENS
Consulting Engineer, Newton, New Jersey

IT IS not a rare occurrence that a flywheel gets loose on the shaft. If the wheel is split, the hub bolts may have come loose, and in that case the nuts may be tightened or the bolts can be taken out, heated and shrunk in. It is, of course, understood that there must be sufficient space between the two halves of the hub for a good clamp fit, the space to be from $\frac{1}{2}$ to $\frac{3}{4}$ in. according to the size of the wheel. A flywheel of the built-up kind getting loose on the shaft is an indication of carelessness in putting it on. The majority of built-up wheels are provided with two hub centers between which the arms are clamped, as shown in Fig. 1. As a rule two feathers are used, both fastened in the shaft. There are, however, instances where each half-center has two separate keys driven in. The center marked *X* is forced on the shaft very tight, while center *Y* is drawn up by means of bolts. Centers and shaft are bored and turned to four different diameters; *A* represents the nominal diameter of the shaft, *B* is bored 0.010 in., *C* 0.020, and *D* 0.030 in. larger than *A*. For *D* and *C* a press fit allowance of 0.001 in. per inch of diameter is made; the allowance for *A* and *B* cannot be more than one-half that amount. The bolts and holes should have a taper of $\frac{1}{8}$ in. per foot. The bolts should have a large fillet under the heads and be driven in tight.

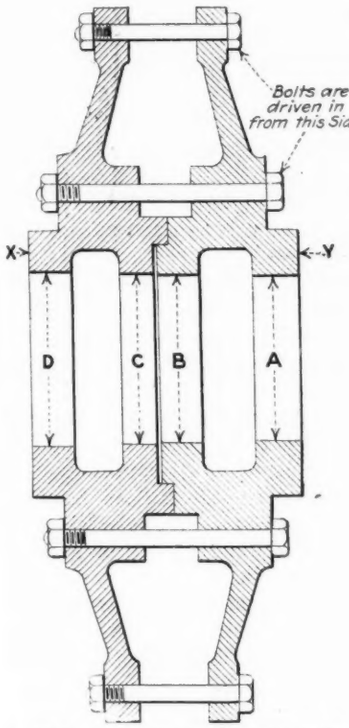


FIG. 1. HUB CENTERS FOR BUILT-UP FLYWHEEL

From the description it is evident that unless the work is carefully done in all its stages, there are some chances of the bolts and the male center working loose. The bolts, or those which get loose, can easily be renewed, but if a center gets loose it is serious. The only remedy will probably be to drill off the loose half and replace it with a new one which is made in two pieces and bolted together as shown in Fig. 2.

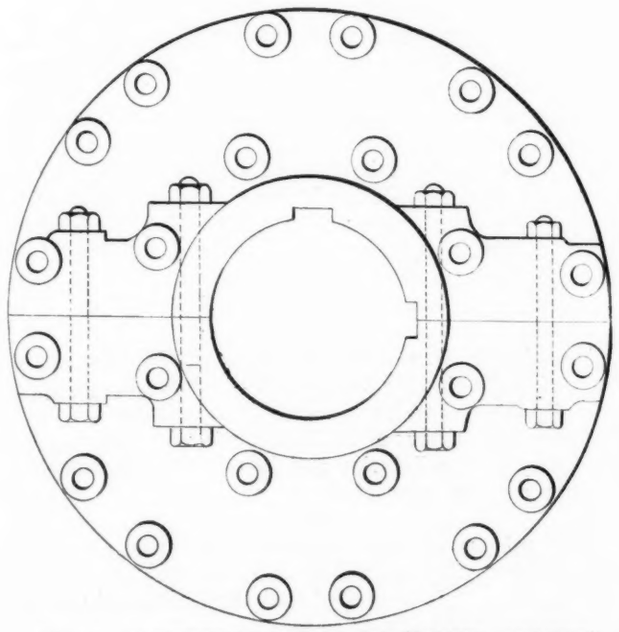


FIG. 2. FLYWHEEL CENTER IN HALVES, BOLTED

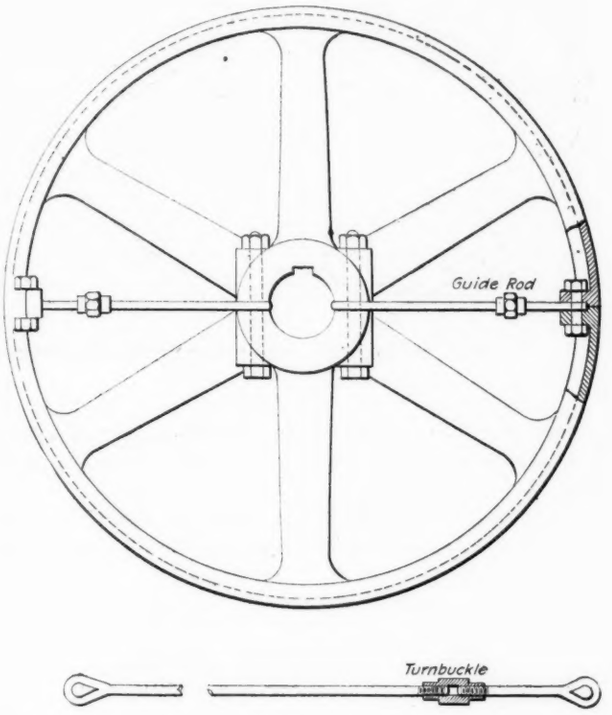


FIG. 3. SPLIT FLYWHEEL STRENGTHENED BY A TIE ROD

Fatigue of the metal due to continuously varying strains in the arms and rims of flywheels is responsible for cracks and failures. The tension in the rim of a flywheel varies as the square of the velocity; it is approximately expressed by the formula $T = \frac{V^2}{10}$, in which V represents the velocity per second. Taking a wheel 16 ft. in diameter with a variation in speed of from 90 to 100 r.p.m., the stresses per square inch in the rim will be 562 and 688 lb. respectively, a change of over 20 per cent. While this is considered to be

well within the limit of safety, it may in the course of time become a source of danger in addition to other strains.

Besides tensile strain there is considerable bending stress in the rim between each pair of arms; this is especially the case in that part where the joint is located between the arms if the wheel is constructed as shown in Fig. 3. For rim velocities of a mile a minute or over the design is dangerous and should not be tolerated. As a safeguard guide rods are often put in between the hub and rim bolts with a turnbuckle for tightening the rod, as shown in the sketch. The rational way to construct a split wheel is shown

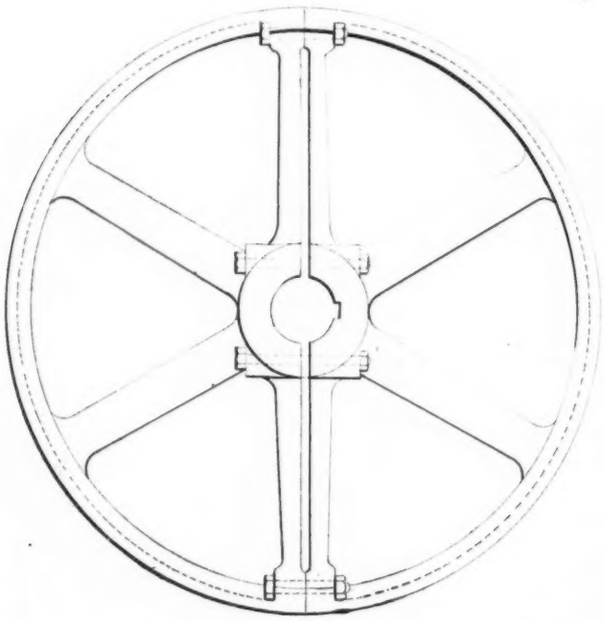


FIG. 4. SPLIT FLYWHEEL WITH PARTING THROUGH THE ARMS

in Fig. 4, in which the parting is through two arms. This design eliminates excessive bending strains at the joints.

Bandwheels should have deep ribs at the edges and in the center, as shown in Fig. 5; *A* shows the design

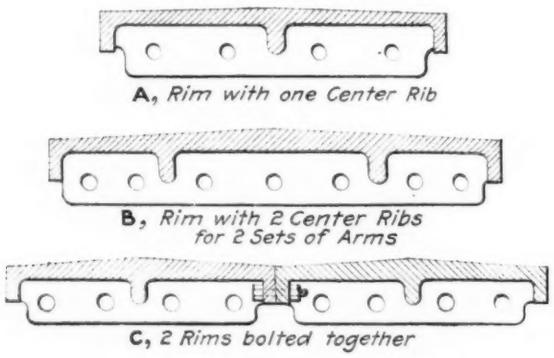


FIG. 5. RIM SECTIONS OF FLYWHEELS

for one set of arms, *B* for a double set, and *C* for very wide faced wheels for two belts in which two separate rims are bolted together through the rim flanges.

For large built-up bandwheels there are several designs extant. In Fig. 6 *A* is perhaps the least desirable as the joints are located between the arms, introducing heavy bending strains; to make these wheels safe guide rods are put between rim bolts and hubs,

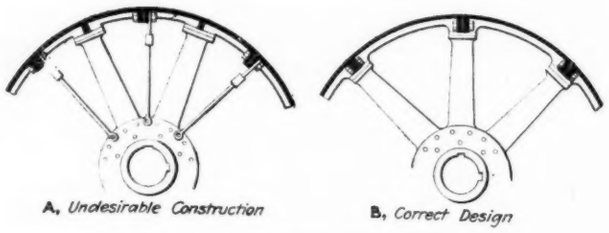


FIG. 6. BUILT-UP FLYWHEELS

similar to those on the split wheel. On the wheel shown in Fig. 6 *B*, the joints are located over the arms, which is the correct place for them. In this design the bending stresses are reduced to a minimum; it is much safer than wheels of the other construction.

Prof. C. A. F. Benedicks, Ph. D. of Stockholm University, has developed a new theory of metallic conduction of electricity which explains certain phenomena not made clear by the former electron theory. As a consequence of this new theory one has to conclude that even in a single homogeneous metal thermo-electric current can be produced. Heretofore such currents were believed to be produced only when two dissimilar metals were present. In liquid mercury it has been possible to definitely prove the existence of thermo-electric currents. During a lecture before the Institute of Metals, London, England, the professor demonstrated a new rotating thermo-electric apparatus made entirely of copper and revolved in a magnetic field, the driving force being obtained solely from unequal heating of strips of copper by means of small gas jets.

It is proposed to divert water from the high-level rivers in Southern Germany to the low-level system of the Main, says the *Electrical Review*, of London. The fall of the River Lech, for instance, which now flows south and joins the Danube, would be increased from 300 ft. to 1,080 ft., resulting in a total of 500,000 hp. if arranged with open canals and falls at three points. The first fall would be at Nuremberg, where 200,000 hp. is obtainable, the second at Wurtzburg, delivering 150,000 hp., and the balance of 150,000 hp. at Frankfort, as against 60,000 hp. if the river is to continue to flow south as at present. Coal-fired installations to produce the same power would require 3,000,000 tons of good-quality coal annually, which at the present price in Germany is worth approximately $70,000,000.

President Wilson has named Secretary Baker as chairman of the Water Power Commission created under the recently enacted water power bill. The other members of the commission are the Secretary of Agriculture and Secretary of the Interior and in addition an executive secretary to be appointed.

Coal miners of France, who have been on strike intermittently for several months, are now said to be all at work. It is computed that the strikes caused the loss of 40,000,000 francs in wages.

John A. Stevens—Authority on Boilers and Power-Plant Design

As a Member of the Original Massachusetts Board of Boiler Rules He Enthusiastically Worked To Form Rules for the Standardization of Boiler Design. Later, his Dynamic Energy Was Largely Responsible for the Successful Formulation of the American Society of Mechanical Engineers' Boiler Code.

Photo by Underwood & Underwood

THERE is a saying that "instead of a man's success being due to a university degree, he often succeeds in spite of it." However, there is a growing opinion that, in the engineering profession, a man rarely attains the highest rank without a thorough technical education. This is true because of the difficulty of obtaining a knowledge of the fundamental principles of engineering outside a high-grade technical school. There have been, however, notable examples of men whose personal ability has pushed them to the top without such help. Such a man is John A. Stevens, the well-known consulting engineer of Lowell, Mass. After graduation from the Saginaw, Mich., high school he attended the University of Michigan for one year, and then left to serve a three-year apprenticeship as a machinist in the shop of Mitts & Merrill of Saginaw; he also worked for about a year as assistant toolmaker with the Pere Marquette Railroad.

Mr. Stevens' experience as a steam engineer began when he turned his attention to marine service on the Great Lakes. He served as engineer on a number of lake steamers, and in 1893 he came East and entered the ocean steamship service in the employ of the International Navigation Co. of New York. He served on a number of this company's liners and received rapid promotion, until in less than three years he was first assistant engineer of the "St. Paul." While in this service he obtained an unlimited engineer's license for ocean steamships—the highest class license issued—at the age of 27 years.

In 1896 he left marine work and became chief engineer of the Merrimac Manufacturing Co., of Lowell, Mass. During the thirteen years he spent in this position, Mr. Stevens practically rebuilt the entire steam plant at Lowell and at the same time superintended the power departments in the company's southern mills.

He resigned his position with the Merrimac Company in 1909 and spent three months in Europe, gathering special information on steam boilers, steam turbines and condensers. On his return from Europe he opened an office as general consulting engineer, specializing however, on light, heat and power work. In this connection he has had a wide experience in power-plant analysis and in the supervision of construction work. Mr. Stevens has also done some original work in the line of invention, having eight patents containing 113 claims on water tube boilers as well as on the American Steam Superheater. He is also co-inventor of the Stevens-Pratt Boiler, which is especially designed for large central-station service.

He is probably best known to the public through his connection with the preparation of steam boiler

standardization codes. He was a member of the original Massachusetts Board of Boiler Rules, representing the "boiler-using" interests. This board was created as a result of the efforts of Mr. Joseph H. McNeil, chief of the Massachusetts Boiler Inspection Department. Mr. Stevens describes the first meeting as taking place in a very small hot room in the State House at Boston on July 5, 1907. At this meeting Mr. McNeil, who was chairman, outlined the plan to formulate a standard for boiler design which should be first of all safe, and second commercial. Meetings were held weekly or oftener for practically three years. Suggestions, ideas and data were solicited and received from all known authorities, various pamphlets were issued and finally the board published the issue of the rules of Aug. 5, 1909. This was the last issue made by the original board and contained all necessary information for the manufacture or inspection of stationary steam boilers in Massachusetts at that time.

In 1911 a committee was appointed by the American Society of Mechanical Engineers for the purpose of preparing a standard boiler code in a more complete manner than was possible with the Massachusetts State Board. Mr. Stevens was made chairman of this committee, which position he still holds. This work was carried on along lines similar to those followed in Massachusetts in taking counsel with all possible authorities who would be interested. In addition to numerous meetings, hearings and much correspondence, an advisory committee was appointed. This advisory committee contained engineers representing every branch of industry interested in boilers either as users, manufacturers, insurers or in any other capacity. A comprehensive code was issued in 1914, and has been adopted in a number of the states.

The committee continues to function and periodically issues information and interpretations of the code in answer to inquiries from those interested. As chairman of this committee, Mr. Stevens has put in a great deal of time and thought and is responsible in no small measure for the success of the work.

During the war he was Standardization Engineer of the United States Shipping Board, Emergency Fleet Corporation and assisted in formulating the "Rules for the Inspection of Marine Machinery."

Realizing as he does the importance of research and invention, Mr. Stevens has taken a practical means to encourage effort in this direction. He has created a trust fund with the American Society of Mechanical Engineers to be known as the John A. Stevens Trust Fund, amounting to $20,000, the income of which is to be paid annually, after 1937, to the persons who have in any year invented or been responsible for the invention of a noteworthy progress in engineering, having to do with the conservation of fuels in the generation of light, heat and power.

In 1918, the Association Medal was presented to Mr. Stevens by the National Association of Cotton Manufacturers for his paper on the "Evolution of the Steam Turbine in the Textile Industry." This medal was awarded to Mr. Stevens for having contributed the most to the advancement of the cotton industry during the year 1917.

Mr. Stevens is a vice-president of the American Society of Mechanical Engineers and a member of the American Society of Heating and Ventilating Engineers, the American Society for Testing Materials, the Society of Naval Architects and Marine Engineers and the Old Colony Club of New York; The National Association of Cotton Manufacturers, and the Engineers Club of Boston, the Lowell Board of Trade and the Yorick Club of Lowell, Mass.; the Vesper Country Club of Tyngsboro, Mass.; The Scituate Yacht Club, the Massachusetts Chamber of Commerce, and the High School Building Commission of Lowell, Mass.

Mr. Stevens was born in Galva, Ill., Sept. 16, 1868. Although a Westerner by birth he comes of real New England stock, being a direct descendant of John Alden.

Spontaneous-Ignition Temperatures of Liquid Fuels

It has long been evident to both designer and user of internal-combustion engines that the influence of the spontaneous-ignition temperature of the fuel was of primary importance. The results of a series of tests by Harold Moore appear in the Jan. 30 issue of the *Petroleum Times*.

In these tests a metallic vessel, having a cavity for the reception of the fuel and oxygen charge, was employed. The vessel was placed on a source of heat, and the temperature was raised until ignition occurred upon the introduction of the fuel and oxygen charge. It was found that, even though the vessel temperature was above the temperature necessary to produce automatic ignition, there was an interval of time elapsing between the introduction of the fuel and the explosion. The time interval is largely dependent on the temperature. Table I covers a test with petrol (gasoline).

TABLE I. TEST WITH PETROL

Temperature, Deg. C.	Time, Seconds	Drops of Oil	Temperature, Deg. C.	Time, Seconds	Drops of Oil
284.5	25	1	299	5.8	1
287.5	14	1	305	4	1
289	12.5	2	310	3.2	1
291	11	1	316	1.6	1
295.5	7	1	320	1.4	1

Table II gives the ignition temperatures of a number of the commonly used fuels. Both pure oxygen and air were employed in the tests. Considering the density of the air charge in an engine cylinder, there is no doubt that the temperature shown when oxygen was the agent more nearly represents actual cylinder conditions.

TABLE II. IGNITION TEMPERATURES OF VARIOUS FUELS

Grade of Fuel	Sp. Gr.	Ign. Temp., Deg. C. With Oxygen	Ign. Temp., Deg. C. With Air	Grade of Fuel	Sp. Gr.	Ign. Temp., Deg. C. With Oxygen	Ign. Temp., Deg. C. With Air
Petrol	0.718	279	361	Texas crude	0.895	256	387
Paraffin oil	0.807	251	...	Fuel oil	0.900	269	430
Petrol	0.735	...	362	Mex. crude	0.908	259	417
Lamp oil	0.787	...	367	Texas crude	0.936	268	416
Gas oil	...	254	358	Mex. fuel oil	0.948	259	424
Egypt crude	0.851	260	...	Mexican crude	0.949	258	425
Degboi oil	0.890	261	384	Calif. crude	0.952	264	
Persian crude	0.894	254	408	Calif. crude	0.961	262	420

In the solid-injection explosive engine, as well as in the Diesel, the temperature at the end of the compression stroke must be high enough to ignite the fuel charge. With the lower pressure hot-bulb engine the temperature during the early part of the compression stroke must not exceed the ignition point. The vaporizer or carburetor engine requires a final temperature below the ignition point.

A curve of the equation $\frac{T_1}{T_2} = \left(\frac{P_1}{P_2}\right)\frac{n}{n-1}$ can be constructed; from this curve the final pressure required in any engine can be fairly determined for any given oil since Table II gives the temperature of spontaneous ignition.

EDITORIALS

Calculating a New Winding for an Induction Motor

IN THE complete design of an induction motor there are in all some nineteen points that must be considered by the designing engineer. Some of these may be compromised to the advantage of the others, depending upon the characteristics it is desired to give to the machine. In fact, the design of any induction motor must be a compromise, since it is impossible to work up a design that will develop high starting torque and operate at high efficiency and power factor, yet will be satisfactory mechanically. If the air gap between the rotor and the stator cover is made of such dimensions as to allow a reasonable wear of the bearing before rubbing will occur between the rotating and the stationary members, then the power factor will be considerably lower than if the minimum clearance is allowed. If the rotor conductors are given sufficient resistance for the machine to develop high starting torque with reasonable starting current, the efficiency of the machine will be low while running. However, some of these features may be favored at the expense of the others to give a design that is best suited to certain applications. Where motors are not required to start under very heavy loads, but run for considerable periods after being started, high starting torque is not as important as high efficiency. Consequently, the motor should be designed to operate at high efficiency. On the other hand, if the motor must start heavy loads at frequent intervals, such as in hoist service, high starting torque with minimum starting current is an important characteristic. Hence efficiency can be advantageously sacrificed to obtain high torque.

In working up a new winding for an old induction-motor core, many of the points that would be considered in a new design are already determined. Furthermore, these designs are in many cases worked up by those who want to know how many turns must be put in the winding and the cross-section of these turns to give a machine that will operate satisfactorily, rather than to achieve refinement in design. A method of "Calculating a New Winding for an Old Induction-Motor Core" is given by A. M. Dudley elsewhere in this issue. Although no attempt has been made by the author to consider all the points pertinent to a finished design, the necessary calculations are given for determining a winding that will give a satisfactorily operating machine in a large percentage of cases. It is the opinion of the author, after fifteen years spent in the commercial design of induction motors and after personal knowledge of many cases of windings roughly calculated by practical winders which performed satisfactorily, that an approximate idea of what is required in a winding to do a certain job can be obtained without involving a great mass of calculation. It should be understood that with the short-cut methods and the abbreviated consideration presented, it is not intended or expected that anyone will produce finished and well-balanced designs; but it is believed that in an emergency, when time is the essence of the consideration and some chances can profitably be taken, the method presented will give an approximation to the correct winding which will be satisfactorily operative in a high percentage of cases. The chief object of the author has been not to elaborate a new system of design calculations, but to tell the fellow whose chief concern it is to make motors run and keep them running, what they may do to help themselves when they are a thousand miles away from a designing engineer and the motor has to be running in the shortest time possible.

Code of Ethics for A. S. M. E.

IN this issue of *Power* is given a summary of the report of the Code of Ethics Committee of the American Society of Mechanical Engineers, together with the complete proposed code. There is nothing new in the idea of such a code. The formal rules of ethics of the various bar associations are well-known precedents. The Mechanical Engineers themselves adopted such a set of rules in 1912, but this document was long and cumbersome and many members, especially those joining the society since that date, have never heard of it.

A reading of the proposed code shows that there is nothing startling in it. It consists of fourteen paragraphs made up of short definite statements of what an engineer is expected to do if he is to have the respect of his fellow engineers. Most of these paragraphs are rules to which any honorable man will agree without question. In fact, the criticism has been made that most of the requirements are so obviously no more than common honor demands that it is unnecessary to formally set them down. It is an unfortunate fact, however, that there are engineers both within and without the society who will violate and who do violate the most obvious of these rules. Such violations of honor are often not violations of law, so that the only punishment is the loss of respect or good will. If a formally stated rule is violated, it is much more likely that the offender will lose his reputation for honorable action than if every individual judged the act according to his own rules.

In general, it is a good code. In fact, it seems to be a very good code. With this idea in mind some criticism of details may be offered for consideration. In the eighth paragraph it is set down that an engineer, before taking over the work of another, should satisfy himself that good and sufficient reasons exist for making the change. It seems that some statement of what would be considered "good and sufficient" reasons is desirable. The tenth paragraph seems contradictory. In the first sentence the engineer is forbidden to regard as his own, information obtained confidentially from a client, while the second sentence allows him to use such information in his own private practice. A few words of explanation might help here also.

The committee, in reporting, suggested that the whole matter should be referred to the Engineering Council or some other body representing all branches of

engineering. The code was presented only to carry out instructions, but the committee feels that men in all branches of engineering as well as architects should have a uniform code. There seem to be good reasons for uniform action by all engineering societies. The main idea in preparing the code is to obtain uniformity among the members of the A. S. M. E.; its extension to include the other branches of engineering should enhance its benefits. It is to be hoped, therefore, that the Engineering Council or the Federated Engineering Societies will take the matter up and carry it on to completion. In this connection the proposed form might well furnish at least a starting point for the work of the more general committee.

The No-Accident Drive

EVERY industrial accident is a setback in the struggle for existence. When it involves human injury, it not only inflicts impairment and suffering upon the immediate subject or brings about the bereavement of those to whom he is dear, but it increases the cost of production. This means either diminished profits to the manufacturer or, if cost is, as it ought to be, the basis of the selling price, a higher price to the consumer.

The results are far-reaching and distribute themselves by devious paths. There is the immediate loss of the material or product destroyed; the loss of production due to interrupted service; the loss of man power through the injury to the victim and consequent upon the interrupted work of other men; the cost of hospital service and medical attendance; the enhanced cost of insurance, predicated upon expectancy of accident and increasing as the number of accidents increases; and numerous others that will suggest themselves to those who analyze the subject further.

Aside from the humanitarian motive of preventing loss of life and physical suffering, there is enough of a material inducement to the manager and to the public to keep the number of industrial accidents at a minimum. The employers' liability laws have made the employing class more conscious of this condition. The large companies are paying a great deal of attention to safety methods and apparatus. State industrial commissions, factory inspecting departments, etcetera are doing good work and the National Safety Council an organization of manufacturers, is attacking the problem in a large and systematic way. Under its auspices the Lehigh Valley in Pennsylvania had a Safety Week. commencing May 10. The extent to which accidents are avoidable is indicated by the fact that during this safety week there was a reduction of ninety-two per cent in mining accidents, eighty per cent in electric-railway accidents, thirty per cent in all public accidents and more than ninety per cent in accidents in the largest industrial plants in the district.

One of the most reproachful of the types of accident that has marred the history of American industry is the boiler explosion; flagrant because the experience of other countries, where their use had been subjected to intelligent and expert supervision and regulation, long ago demonstrated that boilers could be used with a much smaller percentage of accidents than was current in the United States. The attitude toward such legislation, which has been opposed as meddlesome and paternal, is rapidly changing. A third of the states have provisions for the inspection of boilers and some of the states for the examination and certification of the men who run them; and others are coming rapidly to see that supervision is a service rather than an interference.

A Good Suggestion

PROGRESS in any line of endeavor depends very largely upon the reliable data available on the subject, and until these are obtained it is difficult for important developments to be made. This is about the condition that we find in regard to the use of higher steam pressures. Practically all the equipment manufacturers are agreed that the problems encountered in the use of higher steam pressures than those now found in common practice can be solved, but no data are available that would encourage the investment in a plant designed for the pressures that have been suggested. The big question is, How is this experience to be obtained?

Some time ago it was suggested that somebody should build a high-pressure steam plant, but apparently no company cared to take the plunge. Later, efforts were made to have the large power companies form a pool to finance the building of such a plant. However, for various reasons this never materialized. In the Prime-Movers Committee report of the National Electric Light Association, presented at the Pasadena Convention, it was suggested that a trial installation might be made by equipping an existing station with a comparatively small high-pressure boiler and turbine, the latter so designed as to exhaust into the main steam header of the station. This scheme has the great advantage of allowing the work to be done at minimum cost and would show up trouble with valves and piping and furnish a great deal of valuable data on which to base future developments

The White Collar Slave

IN A recent issue the *Electrical Review*, of London, says that at a recent dinner James Swinburne, who, unfortunately, is too seldom seen and heard at electrical gatherings nowadays, pleaded the cause of the salaried men with an earnestness and sympathy which demanded attention.

In view of the commotion recently set up by an advertisement in its pages, which placed a technical officer on a pecuniary par with a fitter, and of Mr. Swinburne's remarks, the arrival of a batch of papers from the Electrical Power Engineers Association embodying particulars regarding the National Joint Board which is dealing with the case of the station men and the schedules of wages agreed upon is very timely. The board will play the part of a Whitley Council for the station, technical and clerical staffs, which are therwise unprovided for in this respect, having been omitted from that scheme by an extraordinary oversight.

The high cost of better grades of coal and the uncertainty of delivery are causing greater use of lignite and low-grade fuels where these are available locally. It has practically become an absolute necessity that the coals be used in certain localities Necessity is the mother of invention, and no doubt in this case will create an incentive to develop improved methods of burning the low-grade fuels.

CORRESPONDENCE

Some Pump Experiences

A triple-expansion duplex mine pump began to perform badly on one side, and as an examination of the water end failed to disclose the trouble, an inspection of the steam end was necessary. Upon opening up the low-pressure cylinder, it was discovered that there was a crack about 14 in. long in the cylinder wall. As this cylinder was live-steam jacketed and worked on a vacuum, a heavy blow of steam through the crack had caused the trouble.

This pump was badly needed, so a quick repair was important. The plan adopted was that of drilling and tapping ½-in. holes and screwing in brass plugs, finishing up by chipping and scraping to a templet that had been formed on the undamaged surface. The first hole was drilled to clear the end of the crack and was at once plugged, each succeeding hole being drilled to overlap the previous plug. A fine and reasonably quick job resulted.

In my younger days I operated a small electric-light station—one where the engineer is also fireman, wireman, lineman, etc. I found a small duplex boiler feeder that had been installed with the machinery, but had been disconnected and set in a dirty corner and a pump, rented from a small local foundry, put in its place. The rented pump had been on the job about six years.

Everyone, particularly the man who owned the rented pump, assured me that the discarded duplex was a bad character, therefore I was curious to see it perform. It had no outside valve gear, but the main valves were moved by double-ended auxiliary piston valves moved by the exhaust on opposite strokes. This pump was of a make I have never since seen.

I placed this pump alongside the other one, connected it up and gave it a good overhauling and inspection, but could see nothing wrong. When steam was turned on, it started and ran for a short time all right, but soon stopped. The auxiliary valves had tappet stems extending through the stuffing boxes on the front of the steam chest and by pulling or pushing on these tappets, the pump could again be started, to run for perhaps an hour, perhaps five minutes.

Odd hours for several weeks were spent in experiments, and the trouble was found to be due to the overtravel of the auxiliary valves, which caused them to cover a small port located near the end of the travel. The cure was to drill and tap ¼-in. holes in the outside faces of the auxiliary pistons, screw in ¼-in. bolts and carefully cut them just the proper length so that when the valve had gone far enough the plug would be in contact with the chest covers. That pump worked faithfully for the three years of my stay.

Notwithstanding the amount of valuable information that has been printed relating to proper piping arrangements and care of pumps, bad piping and sometimes worse handling are much too common. A point of importance in piping arrangement, and one that is more often neglected than provided for, is that of placing an air vent of suitable size on the discharge side of the pump, as close as possible, to aid in starting a pump on a line under pressure, such as a boiler-feed line.

A good pump is a fair performer when handling water, but as an air compressor it is a rank failure, the outside-packed plunger type being especially weak in this respect, owing to its large clearance. Therefore, when a pump has a large volume of suction line to clear of air before water can enter, it is of much importance that it should be provided with ample purge outlet on the discharge.

In a case that came to my notice recently, the suction line to the feed pumps came from a large tank outside the boiler house. This tank is supplied with water by a line from the city main, the flow into it being hand-regulated by the head fireman. On this occasion he allowed the tank to run dry. When the pumps got out of water and ran away, they were shut down and the supply valve to the tank was opened wide to fill the tank as quickly as possible.

The fireman then attempted to start the pumps but, strange to relate, there did not appear to be any water in the suction; in fact, there was nothing but air, due to the rapid filling of the tank. Apparently, neither the fireman nor the watch engineer knew what to do or just what was wrong. The engineer was forced to shut down to save the boilers, and at this stage I was sent in to lend a hand.

Fortunately, the fireman was honest and at once admitted that the tank was empty, thus making clear what was wrong. As there were no vents on this line, the question was how to clear it. This was done by loosening up the covers on the discharge-valve pots, having first closed the stop valve on the discharge line. This case makes four, differing only in detail, that have come to my notice. In each instance a properly placed purge and a few elementary instructions on its use, and on why a pump pumps or does not pump, would have saved a costly shutdown.

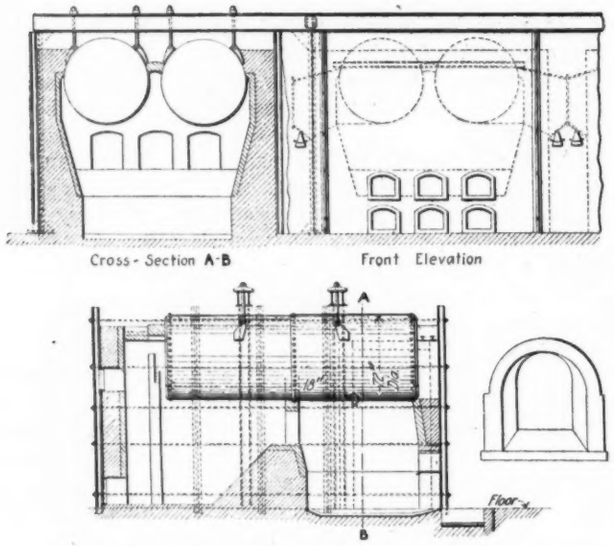
Bellingham, Wash. O. B. CRITCHLOW.

Proposed Setting for Return-Tubular Boilers

Among other power plants we have a boiler house containing six horizontal return-tubular boilers 18 ft. long and 72 in. in diameter. These boilers are from 15 to 20 years old, have been retubed recently, and are in good condition. They have three brackets on each side to support the boiler upon the brick walls of the setting.

The setting is in poor condition, and the side and back walls are badly cracked and bulged. The furnace height (distance from grate to boiler shell) is 38 in. The condition of the setting is such that extensive repairs will soon be required, amounting to almost entirely new walls. Four of these boilers are set in batteries of two, and the other two units are set singly.

My present idea is not to go to the expense of renewing the present setting and finally have the old installation with all its disadvantages, but to go a step farther and set the boilers as outlined in the accompanying sketch, and have in consequence a fairly modern power house. The present height of the building roof would permit a furnace height of at least 60 in., as compared



PROPOSED SETTING FOR TWO RETURN-TUBULAR BOILERS

with 38 in. as now. This increase in combustion volume alone would, it is my belief, increase the efficiency of the boilers.

The boilers would be suspended from beams instead of being supported by the walls, and consequently there would be less strain and fewer cracks on the walls. The radiation losses through the setting and infiltration of air would, in the double setting, be less than in individual settings. This proposed arrangement would combine the advantages of a return-tubular boiler and a water-tube boiler of greater capacity. The capacity of a return-tubular boiler, it is well known, is limited because the shell thickness would increase beyond proportion in boilers of larger diameters than are commonly in use.

I would be glad to read comments about this proposed setting from fellow engineers who may have had experience in this line. M. RIEWERTS.

Passaic, N. J.

Coal Consumption in Institutional Heating Plants

In the April 27 issue of *Power*, page 654, there is an article by G. B. Nichols on "Coal Consumption in Institutional Heating Plants." I think there must be some mistake in the figures given in the tables showing the total savings in ten hospitals. For instance, Manhattan shows the estimated tons of coal consumed as 19,800 and the estimated tons saved as 19,584; Hudson River shows an estimated consumption of 19,051 and an estimate of 2,295 tons saved.

Assuming that the amount saved and price per ton at Manhattan is the same as at Hudson River, the saving at Manhattan would be about 2,376 tons, amounting to $11,832.48 instead of $145,509.12, as shown, or the total saved at the ten institutions would be about 14,117 tons instead of 31,325. The saving would be about $70,302 instead of $200,900. Of course there may be a reason for the saving made at Manhattan, but it is not apparent from the article.

Dannemora, N. Y. FRED CHAPELL.

Recently Inspected Boiler

In a recent issue of *Power* an account of a boiler explosion was published and also a statement by the management of the affected concern that the boiler had lately been inspected. The following may be of interest in showing that a boiler might pass inspection and still have defects that under proper conditions might cause an explosion.

The boiler is of the return-tubular type, 16 ft. long and 66 in. in diameter. It has 105 three-inch tubes; the thickness of the shell is $\frac{7}{8}$ in. The boiler is single-riveted lap-joint and is made up of three courses. It is fifteen years old.

Soot is blown from the tubes by means of a steam lance. One night the fireman was blowing tubes and called me in. He then stuck the end of the steam lance in one of the boiler tubes and turned on the steam. There were two things noticed—a whistling sound and water coming out from the front of that tube. The only reason that appeared feasible at the time was that the tube was partly blocked.

A few days later the boiler was cut out of service. On investigation it was found that three of the tubes were leaking from the rear end. After these were removed, the reason for the peculiar behavior of that one tube became apparent. Small pin holes existed all the way around the tube for a distance of nearly two feet from the end of the tube.

The chief looked over the remainder of the tubes as best he could and it was his judgment that eight more ought to be renewed. The inspector came along and gave the boiler an inspection, followed by a hydrostatic test and claimed that the boiler was all right and that there was no need of renewing the other tubes.

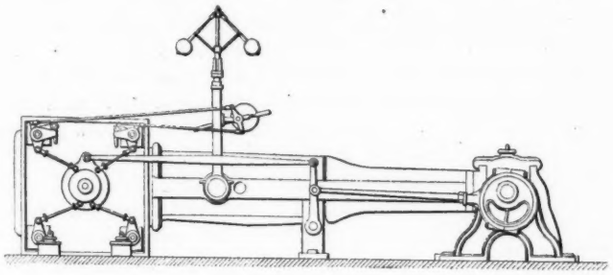
As the chief and the inspector are both human, neither is infallible and either may be right. In view of the fact that the boiler is fifteen years old, safety first would have been a good policy. In conclusion, assuming that, owing to an unforseen cause, that boiler has to be forced for all its worth and a rupture occurs, the management is perfectly right in saying: "It had been recently inspected." Poor consolation for the victims!

Bayonne, N. J. THOMAS M. GRAY.

Testing for Twisted Valve Stems

Setting the valves of a double-eccentric Corliss engine is usually performed according to the idea of the engineer who is doing the work. I have had quite a number of years' experience with both double- and single-eccentric engines and have found that twisted valve stems or incorrectly keyed valve cranks sometimes present perplexing conditions.

In testing Corliss valves for such defects, first plumb both rocker arms and both wristplates. Then take a



ROCKER ARM, WRISTPLATE AND VALVE ARM PLUMB

wrench and a square and, paying no attention to the threads on the rods, the valve lap, or the valve opening, lengthen or shorten the steam and exhaust rods until the steam and exhaust valve cranks and rods stand at right angles, as shown in the sketch. Then look at the lap on the exhaust valves and at the opening of the steam valves, see that both steam rods measure alike, center to center, and also that both exhaust rods measure the same, center to center. If the steam valves show about $\frac{1}{8}$-in. opening and the exhaust valves show line and line, they are all right; but if not, either change the keys or put in new valve stems keyed to this position.

When this has been accomplished, place the crank on either dead center and move the steam eccentric in the direction the engine is to run until there is a $\frac{1}{16}$ in. opening or lead. Then fasten the eccentric to the shaft and turn the engine in the direction the engine is to run until the piston has moved in $2\frac{1}{2}$ in. of its stroke and fasten the exhaust eccentric to the shaft.

Next place the crosshead at a point $22\frac{1}{2}$ in. of its stroke, with the governor resting on the safety latch, and set the knockoff clips so that they will just touch. Next adjust the safety clips, put on the steam and exhaust caps and start the engine. Then take some diagrams and adjust the steam eccentric so that the admission line is at right angles to the steam and back-pressure line. If necessary, move the exhaust eccentric in the direction that will give the proper amount of compression to just take care of the slack of the crosshead and crankpin brasses. J. A. AVERY.

Eaton, Ind.

Operating Diesel Engines

I do not agree with G. J. Trosper in his article on operating Diesel engines, in *Power* of June 8. His ideas as to the proper temperature for the cooling water are correct, but I would dislike to operate a plant where his cooling system is installed.

He shows the cooling water circulating through a closed system and being cooled by a set of coils. Of course it is quite possible to cool the water in this way, but the amount of water handled through the coils will be at best four times the amount circulated through the engine jacket. The power required, and the size of cooling pond or spray system, are correspondingly increased.

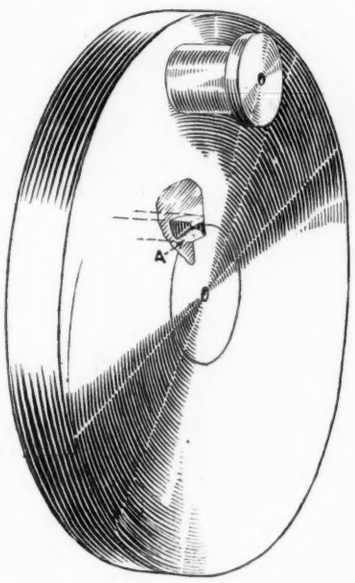
Furthermore, he will find that the thermostatic control regulating the amount of water flowing through the coils is not sensitive to changes in load. It is apparent that with an increase of load, the discharge temperature will rise; this will act on the cooling-coil valve, increasing the flow through the coils, which will lower the temperature in the tank. It will take some time before this increased flow affects the temperature in the box, and in the meantime the jacket temperature will become exceedingly high.

In localities where the water is bad, the proper course is to install a water-treating plant. The cost of treating will not exceed one-half cent per horsepower per day. In England, distillers, using the heat in the exhaust gases, are being manufactured and are coming into general use. With the distiller fresh water is evaporated at atmospheric pressure and, after condensation, is added to the cooling-water system. The distiller is so arranged that scaling is easily accomplished. E. E. SNOW.

New York City.

Two Arc Welding Jobs

On one occasion the plungers of an outside-packed pump became badly scored, due to gravel in the water, some of the grooves being very deep. The deepest grooves were filled by means of the arc welding process, and the metal was then smoothed down by grinding.



WELDED KEY IN PLACE

This enabled the pump to do duty until new plungers could be obtained.

The key in the crank of a small vertical double-crank engine became loose and worked out. As the engine had to run until a better opportunity for repairs arrived (a short piece of shaft and reboring the crank was necessary), a small piece was chipped off one side of the key and a little knob of metal built up on the shaft in the keyseat, as shown at *A* in the sketch, which shows the shaft and key, but not the crank.

Toronto, Ont., Canada. R. MCLAREN.

Capacity of Steam Pipe with Superheated Steam

Some months ago a reader asked in the columns of *Power* for information regarding the steam flow through a 10-in. extra-heavy pipe, but just what information he desired was not made clear. The calculations given herewith are offered with the hope that they may throw some light on the subject.

It appears that he had been conveying 70,000 lb. of steam per hour through this line, with 105 lb. pressure at the receiving end of the line, with 15 lb. drop in pressure in a 600 ft. line, containing two globe valves. A 10-in. globe valve is equal to approximately 70 ft. of line, which would make this line equivalent to 740 ft. in length. It is evident that there is some error in his measurements, or calculations, as to the quantity of steam that he was using at 600 deg. F.

Kent gives the following formula for determining the weight of superheated steam:

$$D = \frac{1.684 \times P}{t + 461} \qquad (1)$$

where D equals the weight of steam per cubic foot; P equals the pressure, pounds per square inch, absolute; and t equals the temperature in degrees F.

Substituting in the formula and solving for D, we have:

$$D = \frac{1.684 \times 120}{600 + 461} = 0.191 \text{ lb. per cu.ft.}$$

At 400 deg. F. the weight is 0.234 lb. per cubic foot.

"Steam Piping," by Johnson, page 7, gives the following formula, for determining the weight of steam flow, pounds per minute:

$$W = 87 \left[\frac{p \times D \times d^5}{\left(1 \frac{3.6}{d}\right) L} \right]^{\frac{1}{2}} \qquad (2)$$

where W equals the weight of steam flowing, in pounds per minute; p equals the pressure drop in pounds; D equals the density, or weight of steam per cubic foot; d equals the internal diameter of pipe in inches, and L equals the length of pipe in feet.

Substituting the known values in the formula and solving for W, we have:

$$W = 87 \left[\frac{15 \times 0.166 \times (975)^5}{\left(1 + \frac{3.6}{9.75}\right) 740} \right]^{\frac{1}{2}} = 1{,}370 \text{ lb. per min.}$$

or 82,400 lb. per hour.

Steam at 120 lb. per sq.in. absolute and 600 deg. F. contains 1,322.4 B.t.u. per pound, and at the same pressure and 400 deg. F. contains 1,222 B.t.u. per pound. If we multiply the number of pounds of steam used at the higher temperature by 1,322.4, we get 108,900,000 B.t.u. Then dividing this quantity by 1,222 will give the weight of steam at 400 deg. F. to give the same heat value, which is 89,100 lb. per hour.

If we substitute all the known values for steam at the lower temperature, in equation (2) and solve for p, the pressure drop, we find that he has a drop of 14.3 lb. approximately, which is only about 7 per cent less drop instead of the 20 per cent that Mr. Remol had calculated he would have. F. C. DEWEESE.

Joplin, Mo.

Lubrication Was Neglected

I read with interest the letter in the June 8 issue of *Power*, page 932, by Hugh G. Boutell, on "Lubrication Devices Neglected." It brings to mind what happened on the tugboat on which I am employed.

I had the after engineer watch, going on at 12 and off at 6 o'clock. The chief had the forewatch, 6 to 12. The tug is equipped with a good steam steering gear, but one day the pilot told me it stuck when put to starboard but would go to port all right. A sight force-feed oiler lubricator was used with the equipment, together with a pressure oiler on the stuffing box. When we tied up in Tonawanda, I took the force-feed pump apart, as I suspected the machine must be dry, and I found that the pipe was nearly filled with dirt. The bull's-eye was plugged, and the bottom check of the pump contained a piece of dirt that prevented the ball from seating. After cleaning all parts, I pumped kerosene through the lubricator. Then I filled the pressure oiler on the gland and cleaned out all oil holes and the steering gear worked satisfactorily.

The reason things got into the condition they did was because the chief refused to overhaul the lubricator on the steering engine, saying it was the mate's job. As we had no mate, I did it. On the same day, before cleaning the lubricator, it was necessary to pass under a temporary bridge that was packed with people; when the steering gear refused to work we hit that bridge.

Buffalo, N. Y. G. S. ROLLINS.

Pure Water for Boiler Feed

Years of practical operating experience have convinced many an engineer that Mr. Rose's version regarding pure feed water, as published on page 784 of the May 11 issue, is correct. Large or small heating boilers using the same water over and over again show signs, on inspection, of pitting. The same boiler will furnish steam in a power plant, using the same water as used in the heating boiler without signs of pitting.

Two boilers formerly used in a theater for lighting and heating purposes gave a very good demonstration of this phenomenon. No signs of pitting were in evidence until about a year and a half after the engines were removed. Then severe pitting took place, due, in all probability, to pure water. Of course, in the 50,000-kw. plant the boilers will be of the water-tube type and perhaps will not pit so rapidly. C. W. PETERS.

New York City.

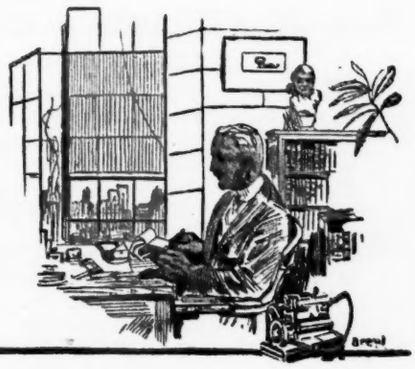
A Correction

We note with interest in your issue of June 22 an article on "Steam-Jet Air Pumps for Condensers," by DeWitt M. Taylor.

On page 996 the statement is made that the Croll-Reynolds Evactor is manufactured by the Ross Heater and Manufacturing Co., of Buffalo, N. Y. This statement is incorrect, as we are the sole designers and manufacturers of the Evactor. The Ross Heater and Manufacturing Co. formerly manufactured on a royalty basis according to our designs and drawings, a small number of Evactors. The arrangement which we had with this company was discontinued in February of this year, and we would, therefore, ask that you kindly make this correction in your next issue.

New York City. CROLL-REYNOLDS CO., INC.

INQUIRIES OF GENERAL INTEREST



Allowable Blowdown of Boiler Safety Valves—What should be the amount of blowdown of a boiler safety valve? G. N. H.

The amount of blowdown admissible depends on the boiler pressure that is carried. The A. S. M. E. boiler code stipulates that safety valves on boilers carrying an allowed pressure of less than 100 lb. per sq.in. gage must be adjusted to close after blowing down not more than 4 lb.; when carrying pressures 100 to 200 lb., the blowdown must be not over 6 lb.; and when carrying over 200 lb., the blowdown must not be more than 8 pounds.

Causes of Boiler Priming—What causes a boiler to prime or deliver wet steam? M. R.

Priming may be caused by insufficient steam room, insufficient water surface for the disengagement of steam without violent ebullition, improper location of the steam pipe, dirty water, or may result from forcing or overcrowding the boiler. Insufficient steam room and insufficient water surface may be due to faulty design or carrying the water level too high. The use of muddy water or water containing cylinder oil is likely to cause foaming, and the violent ebullition that results from forcing a boiler may cause particles of water to be projected high enough into the steam space to be swept into the steam pipe.

Hollow Walls for Boiler Settings—What is the advantage or disadvantage of hollow walls for boiler furnaces? F. A.

So far as direct loss of heat is concerned, there is rather more heat lost by radiation through air-space walls than through solid walls of the same total breadth, especially if the air space is near the furnace side, as air offers less resistance to radiation than brickwork. A hollow wall is better than a solid wall to prevent cracks from expansion of the brickwork on the furnace side, but when this construction is adopted, the cavity should be filled with solid loose material to prevent radiation of heat from the inner to the outer wall and retard circulation of cold air entering the cavity through openings or cracks that may occur in the outer wall.

Testing Indicator Reducing Wheel—How can the accuracy of an indicator reducing wheel be tested? E. T. B.

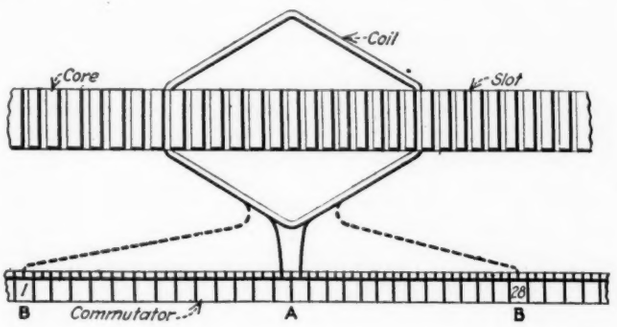
Set the indicator on the engine or any stationary support, and fix a rod or board having a straight edge that will be followed by the cord when drawn out a distance equal to the stroke of the engine, and lay off the length of stroke along the straight edge and divide it into four or more equal parts, and drive small and equal-sized wire nails at the points along the straight edge that represent the ends of the stroke, and at each of the subdividing points. Then, with a spring in the indicator and a blank card on the paper drum, strike a long atmospheric line by drawing out the cord by hand and light pressure on the pencil. Having the cord of proper length so it will not cause the drum to strike its stop when the hook is on either of the nails that represents the end of the stroke, place the hook on one nail after the other, each time lightly pressing the pencil on the card, and making a short mark across the atmospheric line. If the reducing motion is correct, these marks will be equally spaced.

Power Input to Induction Motor—How is a 10-hp. three-phase 440-volt induction motor tested to determine if it is underloaded? Can an ammeter be used for testing? P. M.

An ammeter reading of an induction-motor load is of little import unless the power factor is known. Since the power factor of an induction motor decreases as the load is reduced, the current will not be reduced in proportion to the load. An induction motor operating at 50 per cent load will take approximately 80 per cent of the full-load current, but the power factor will be in the neighborhood of 0.70, where at full load it is about 0.87. The most satisfactory way to measure the power input to an induction motor is with a polyphase wattmeter, and then allow 900 watts per horsepower output, to obtain the mechanical load on the motor. About the only thing that an ammeter would show is whether the motor is overloaded or underloaded.

Reconnecting Direct-Current Generator—We have a 120-volt direct-current generator and wish to reconnect it to operate on 220 volts. The machine has four poles, and in the armature there are 56 coils, and 56 segments in the commutator with the coils grouped in a four-circuit winding. Can the fields and armature coils be regrouped to give the higher voltages? W. O. R.

By regrouping the armature coils into a two-circuit, or series winding, it will develop double the present voltage with the same field density, or 240 volts. The difference between 240 and 220 or 20 volts can be easily taken care of by adjusting the field rheostat. As the coils are now



grouped, the leads of each coil are connected into adjacent segments, as shown at *A*, in the figure. Fifty-six coils cannot be connected into a series winding, but 55 coils can, therefore it will be necessary to leave one coil dead in the winding and connect two of the segments together. The leads of the coils will then be connected so as to span 27 segments, or from 1 to 28, as at *B* in the figure. In order that the field coils will operate on the new voltage, they will have to be rewound with the present weight of wire of one-half the cross-section of that now used in the coils. In all probability a new field rheostat will be required for the higher voltage, to obtain proper adjustment of the voltage.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. —Editor.]

Translating Oil Into Steam Must Cease*

By Eugene Mcauliffe

Within twelve months the fuel-oil situation, in so far as present and future supply, as well as unit costs, are concerned, has undergone startling changes. One year ago we were alone concerned with the economical consumption of fuel oil. Today there is a national feeling that the period of fuel-oil consumption for steam-making purposes is substantially behind us.

The oil industry of the United States is but sixty years old. On Aug. 28, 1859, Colonel Drake struck oil in a well 69 ft. deep, near Titusville, Pa., the well pumping forty barrels per day and later shrinking to fifteen barrels daily. The oil fields of Pennsylvania, West Virginia and Ohio quickly gained extraordinary prominence. In the early sixties oil was discovered in southern Russia, and a British engineer, working with a Russian photographer, invented an oil burner. Later, Thomas Urquhart, a British locomotive superintendent, equipped certain Russian railway locomotives to burn Russian fuel oil.

For steam-making purposes the tide of oil burning has ebbed and flowed ever since with the discovery and exhaustion of recurring fields, each extraordinary oil development leading to the displacement of coal for steam-making purposes on the part of railways, steamship owners and industrial users. In every instance, when the inevitable exhaustion of the oil fields occurred, steam consumers went back to coal for fuel purposes. Looking back a few years, we have but to recall the famous Spindle Top field, located near Beaumont, Texas, where a small dome-shaped area, approximating 260 acres in extent, produced in a few months 37,000,000 bbl. of oil. This field came cataracting in with the famous Lucas gusher, which flowed 75,000 bbl. daily; later, Heywood No. 2 came in with 96,000 bbl. in 24 hours, this well producing 1,395,000 bbl. of crude oil in its glorious life of ten months.

These were the days of ten-cent oil, and the railroads in southern central territory followed the example of Urquhart, by taking advantage of cheap fuel produced at their very doors. In the meantime southern California was developing heavy oil production in a territory where coal, owing to long rail hauls over mountain grades, was relatively high-priced, and the railroads reaching California territory joined the ranks of fuel-oil consumers. Later, the famous Glenn, Oklahoma, field swung into line, the exhaustion of that field followed by the development of the great Cushing field, which, when it began to decline, was followed by the development of the Burke-Burnett, Texas, field.

Development of the Mexican Fields

In 1909 and 1910 the great oil development in Mexico was well under way. In November of last year Juan Caisno No. 4, after producing 75,000,000 bbl. of oil, went to salt water in a few hours. This startled the Mexican oil producer, and gradually the news trickled out to the oil-consuming world that the great Mexican oil fields had limitations, such as those experienced in the fields developed north of the Rio Grande. A month later Portrero del Llano, of the Mexican Eagle Oil Co., Lord Cowdray's British organization, after producing 110,000,000 bbl. of oil at the rate of 16,000,000 bbl. annually, swung over to salt water in a few hours. Then, on Feb. 21 of this year, Tepetate No. 1, of the Cortez Oil Corporation, followed suit. Meanwhile numerous less-prominent producers have gone the way of all good oil wells.

While the effect of this situation was startling, perhaps the rude awakening suffered by the Navy Department more thoroughly alarmed the oil consumers of the country than did anything else. After practically effecting the consummation of a very extensive oil-burning program, the Navy Department asking in March last for Pacific Coast bids on 4,500,000 bbl. of fuel oil, received but one bid covering a delivery of but 602,000 bbl., at a price of $1.95 per barrel. In April bids were requested for Atlantic Coast deliveries. Five tenders were returned, covering an entirely insufficient supply, the price for bunker oil ranging from $2.07 to $3.76 per barrel of 42 gallons. A similar fuel problem confronts the American merchant marine, the completed program of the United States Shipping Board aggregating 10,000,000 dead-weight tons, of which 2,000,000 tons will consist of coal-burning vessels, and 8,000,000 tons of oil-burning vessels. The estimated fuel-oil requirements of the Shipping Board for the year 1920 are forty million barrels; for 1921, sixty million barrels.

When it is considered that the necessity for maintaining a navy will not cease until the end of the existing generally used form of government, or until the millennium arrives, both of which are perhaps quite remote, it would seem plain that the requirements of the United States Navy, equipped to carry and burn oil will take precedence over any other demand, and it is equally reasonable to assume that after the American people have spent billions in the upbuilding of an American merchant marine, its fuel-oil requirements will take position only second to that of the battleships. The statement of men who should know, that 1920 and 1921 will mark the peak period of oil production, with a steady decadence from this time forward, justifies serious consideration of the oil problem. The United States Geological Survey estimates that with the close of the year 1919 we have taken approximately five billion barrels of oil out of the ground; the estimated oil reserve yet in the ground is six and one-half billion barrels.

Fuel-Oil Situation Precarious

Dr. George Otis Smith, in a paper presented before the American Institute of Mining and Metallurgical Engineers, said:

". . . the position of the United States in regard to oil can best be characterized as precarious. Using more than one-third of a billion barrels a year, we are drawing not only from the underground pools, but also from storage, and both of these supplies are limited. In 1918 the contribution direct from the wells was 356,000,000 bbl., or more than one-twentieth of the amount estimated by the Survey geologists as the content of the underground reserve; we also drew from storage 24,000,000 bbl., or nearly one-fifth of what remains above ground.

In a single decade the consumption of fuel oil by railroads has more than doubled; the consumption of gasoline has increased sevenfold. We may lessen the increase in coal or oil consumption for generating power by harnessing the water powers of the country, but these prime movers, whether driven by steam or water, require lubrication. With the rapidly increasing use of machinery to make labor more productive, with the almost universal use of the automobile, hardly foreseen a decade ago, and with the expected increase in railroad and steamship traffic, who can venture an estimate of petroleum requirements ten years hence in terms of lubricating oil alone?

While we have great reserve of oil shales as an independent source of fuel oil, gasoline and lubricating oil, to develop this supply on a scale comparable in output with our present oil supply would require an industrial organization greater than our entire coal-mining organization. Plainly, the country cannot afford to support another such army of workers until we reach another stage in our industrial development.

Between 1909 and 1918 the number of automobiles and trucks increased 1,700 per cent; and the consumption of gasoline for automobile purposes jumped from 13,000,000 to 85,000,000 bbl., or 650 per cent, while the production of crude oil increased 95 per cent. Today we operate 7,600,000 automobiles and motor trucks and 350,000 tractors, and the 1920 construction program totals 2,000,000 automobiles and motor trucks. The Government has thrown open for drilling 6,500,000 acres of national oil reserve, but these lands located in California and Wyoming will not add materially to the supply. In 1919 29,000 wells were driven to success or failure. Of these 6,000 were dry and 2,000 returned gas without oil. The drilling expense is estimated at $600,000,000.

Only twelve years ago it was difficult to force the skimming plants of Texas and Oklahoma to take sufficient gasoline out of the crude to make its use on a locomotive safe. The railroads, which then absorbed the residue left after the taking off of the lighter distillates, built up a comfortable refinery traffic for their rails, but a complete return to coal fuel is now imminent.

*Excerpts from paper presented before International Railway Fuel Association, Chicago, May 24-27.

Standardization of Pipe Flanges, Fittings and Shafting

The American Society of Mechanical Engineers has been requested by the American Engineering Standards Committee to assume sponsorship in the standardization of pipe flanges and fittings and shafting. In 1914 the society issued a report covering a schedule of pipe flanges and fittings, for diameters from 1 in. to 100 in. for 125 lb. pressure, and also a schedule for extra-heavy pipe, covering a range from 1 in. to 48 in. diameter, and for 250 lb. pressure. In 1918 a supplementary report was published for working pressures of 50, 800, 1,200 and 3,000 pounds.

While the work has not been active during the last year, it is now proposed that it be continued, the society being formally recognized as sponsor, under the rules of procedure of the A.E.S.C.

The society has already done a considerable amount of work on a set of standard diameters for transmission and machinery shafting. It is proposed that the work, which will be carried out by a sectional committee working under the rules of procedure of the A.E.S.C., shall be broadened to include the standardization of the method of determining what diameters of transmission shafting should be used for given loads, the dimensions of shafting keys and keyways, and the setting of dimensional tolerances.

German Turbine of 75,000 Horsepower*

The large steam-turbine units built in Germany during the war are headed by the 75,000 hp. turbines of the Goldenbergwerk of the Rhenish Westphalian Electric Supply Co., in the vicinity of Cologne.

Fig. 1 gives a view of this machine, the proportions of which may be gaged by the human figures standing alongside. Turbine and generator are designed for an output of 60,000 kva., corresponding to roughly 75,000 hp. at 1,000 r.p.m. The potential of the alternators is 7,000 volts between phases. The steam pressure amounts to 170 lb. per sq.in. and the steam temperature to 617 deg. F. The turbine is provided with two condensers, of 32,000 sq.ft. of cooling surface each, corresponding to a cooling-water temperature of 27 deg. C. The weights of the principal parts are:

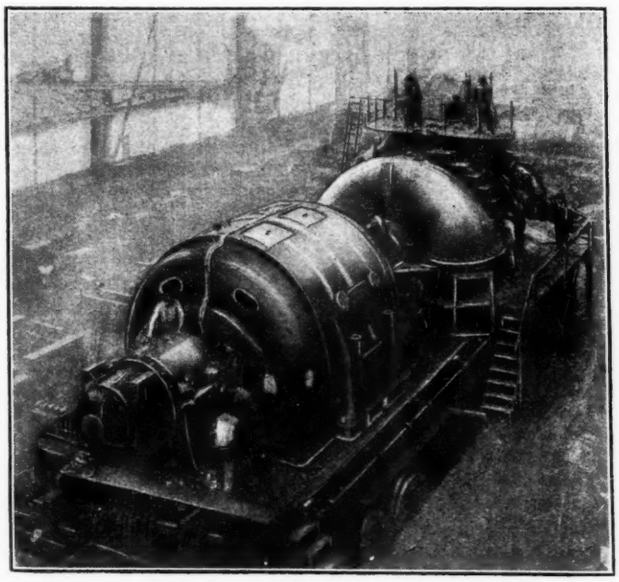


FIG. 1. GERMAN TURBINE OF 75,000 HP. (60,000 KVA.) 1,000 R.P.M. OF STANDARD A. E. G. CONSTRUCTION

Turbine complete, 250 tons; turbine rotor, 49 tons; dynamo complete, 225 tons; dynamo rotor, 106 tons; condenser, 100 tons.

The turbine is fitted with ten runner wheels—one double-bladed wheel for the high-pressure stage, and nine single-bladed wheels toward the low-pressure end. The diameter of the wheels is between 3,400 and 3,800 mm., corresponding to a circumferential velocity of 590 to 655 ft. per sec. at 1,000 r.p.m. As no high-grade nickel-steel was available for the blading, as before the war, the design of the blades at the point of maximum strain had to be altered to suit the circumferential pressure of the steam and the centrifugal forces in the rotor. This was accomplished by milling the blade out of a solid piece of steel equal to the thickness of the blade plus the thickness of the filling piece. The blade and filler were thus made in one piece and the blade was chamfered down toward the tip. Only about 15 per cent of the original metal was left after the blade and filler had been finished in this way.

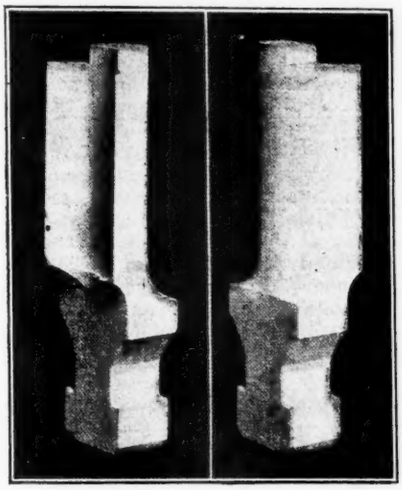


FIG. 2. THE BLADE AND FILLER WERE MADE OF ONE PIECE

Fig. 2 shows blades of this description. The bearing surfaces of the rotor have a diameter up to 600 mm. with a circumferential velocity of about 100 ft. per sec. Each turbine has two outlets for the exhaust steam, of 2,500 mm. diameter each, one for each condenser.

It is typical of this design that the entire power is generated in one turbine case and in one alternator. The design is the standard Allgemeine Elektrizitäts-Gesellschaft (A. E. G.) construction with three main bearings, the center one being designed as a double bearing to reduce the specific bearing pressure. According to A. E. G. practice the two rotors are connected by a rigid flange coupling mounted between the bushes of this center-bearing.

The governing is on the standard A. E. G. method; that is, by throttling the steam nozzles singly or in groups by valves which are closed, one after another, by a camshaft. This camshaft is driven by a servomotor.

National Electrical Safety Code Almost Completed

The present edition of the "National Electrical Safety Code" was issued in 1916 for examination, trial and constructive criticism. It was realized that the code was not a perfected document and that experience should be obtained with it before the rules were made mandatory. War conditions delayed the expected trial, and although revision has been almost continuously under way, it was not until the present year that sufficient information and consideration of the rules could be obtained to warrant the publication of the new edition.

*From *Engineering Progress.*

The text of the new edition is now almost completed. Two lists of proposed changes in the various parts of the code have been circulated for criticism, the latter of these being issued in May of this year. Comments upon these have now been received, and the bureau is about ready to go to press with the revised edition. Points upon which disagreement exists have been solved almost entirely, with respect to the rules governing power stations and those governing utilization apparatus and the grounding of circuits and equipment. The rules dealing with overhead-line construction have always been the most difficult to handle on account of the widely differing opinions regarding such construction on the part of the various utilities. It has not been possible to secure complete agreement on this part of the rules, and future revisions in this part of the code will, no doubt, be more intensive than in the other parts. They will involve the collection of more complete data and probably the carrying out of experiments to determine appropriate strength requirements.

It is expected that copies of the new edition of the code will be available late in the summer. It will be printed in pocketbook size, and the discussion of the rules will be entirely segregated from the rules themselves, probably being placed under a separate cover. A pictorial edition of the code, in which the meaning of the rules will be shown largely by illustrations, is in contemplation.

A. S. M. E. Discusses Proposed Code of Ethics

At the spring meeting of the American Society of Mechanical Engineers in Detroit, June, 1919, a committee was authorized to prepare a Code of Ethics for Mechanical Engineers. At the meeting of the society in St. Louis, May, 1920, this committee reported and submitted a brief code. The report suggested that such a code should be a brief, positive statement of the professional relations of engineers to the public, to their clients or employers, and to one another.

Since the work of engineers of every branch of the profession as well as that of architects is closely associated with the mechanical engineer's practice, the committee considers that such a code should be common to all these branches. It was therefore recommended that the matter be referred to the Engineering Council or a similar joint professional body for action to be later approved by the society.

In case such action appeared to be undesirable, the committee submitted the appended code for the society's consideration. The code, as presented, was accepted as a first reading at the St. Louis meeting and will come up again at the annual meeting. It was also referred to the Engineering Council for recommendation to the Federated Engineering Societies.

1 The mechanical engineer should be guided in all his relations by the highest principles of honor, of fidelity to his client, and of loyalty to his country.

2 His first duty is to serve the public with his specialized skill. In promoting the welfare of society as a whole he advances his own best interests, as well as those of the whole engineering profession.

3 He should consider the protection of his client's or employer's interests in professional matters his essential obligation, provided these interests do not conflict with the public welfare.

4 He shall refrain from associating himself or continuing to be associated with any enterprise of questionable or illegitimate character.

5 He can honorably accept compensation, financial or otherwise, from only one interested party unless all parties have agreed to his recompense from other interested parties.

6 He must inform his clients of any business connections, interests or circumstances, such as might influence his judgment or the quality of his services to his clients.

7 He must not receive, directly or indirectly, any royalty, gratuity or commission on any patented article or process used in the work upon which he is retained without the consent of his clients or employers.

8 He should satisfy himself before taking over the work of another consulting engineer that good and sufficient reasons exist for making the change.

9 He must base all reports and expert testimony on facts or upon theories founded only on sound engineering principles and experiences.

10 He must not regard as his own any information which is not common knowledge or public property, but which he obtained confidentially from a client or while engaged as an employee. He is, however, justified in using such data or information in his own private practice as forming part of his professional experience.

11 He should do everything in his power to prevent sensational, exaggerated or unwarranted statements about engineering work being made through the public press. First descriptions of new inventions, processes, etc., for publication should be furnished only to the engineering societies or to the technical press.

12 He should not advertise in an undignified, sensational or misleading manner, or offer commissions for professional work, or otherwise improperly solicit it.

13 He should not compete knowingly with a fellow-engineer for employment on the basis of professional charges or attempt to supplant a fellow-engineer after definite steps have been taken toward the other's employment.

14 He should assist all his fellow-engineers by exchange of general information and valuable experience or by instruction through the engineering societies, the schools of applied science, and the technical press.

Standardization Organizations in Europe

In a report to the American Engineering Standards Committee outlining the meeting of the International Electrochemical Commission in Brussels, P. G. Agnew, secretary of the American Engineering Standards Committee, also makes note of the various European societies and organizations engaged in the promotion of standardization in engineering practice.

In 1919 the Comite Central Industrial de Belgium, an organization which is playing an important rôle in Belgian reconstruction, organized the Association Belge de Standardisation. There is a main committee and working committees. The actual standardization work is carried out under the direction of the main committee and the details of administration are handled by the central office. Comprised in the work already carried out are a standard series of bolts and rivets. Work now on hand includes reinforced concrete, mechanical power transmission, water-pipe fittings, specifications for steel bridges, economics in coal consumption and steel sections.

The Commission Permante de Standardization of France differs from other national standardizing organizations in that it is strictly an official body and supported wholly by government funds. It is attached to the Ministry of Commerce, Industry, Posts and Telegraphs, Maritime Transport and the Merchant Marine. The actual technical work is in charge of fourteen subcommittees.

The main committee for standardization in the Netherlands, known as "Hoofdeommissie voor de Normalisatie in Nederland," was organized in 1916 by the Society for the Encouragement of Industry and the Royal Institute of Engineers.

Each of these societies names two members of the main committee the total membership of which is fifteen. The other eleven members are appointed by the committee itself. The president, vice president and treasurer form a small executive committee which meets frequently. There are four regular meetings of the main committee each year. The main committee is not responsible for details, but is responsible for procedure and for the representative character of the committee in immediate charge of the detailed work.

The British Engineering Standards Committee was organized in 1901 by five leading technical societies. In 1918 the name was changed to Association. The general direction of affairs is in the hands of the main committee, which constitutes the sole executive authority. Sectional committees are responsible for the technical work.

Fuels Section of the A. S. M. E. Adopts Program

A meeting of the subcommittee on Meetings and Papers of the Fuels Section of the American Society of Mechanical Engineers was held at the headquarters of the Society on Friday, June 18, Prof. George A. Stetson, David Moffat Myers, Henry Kreisinger, W. E. Bullock, assistant secretary, and C. E. Davis, of the office staff, being present. The participation of the section in the program of the annual meeting in December was discussed, and the papers outlined as follows:

1. Fuel Supply of the World—A census or, rather, an inventory, of the world's supply of fuels, coal, lignite, peat, oil, oil shale, natural gas, alcohol, etc. This subject would be treated from the standpoint of location of supply as related to localities of consumption and should be a broad survey from the world's standpoint with reference to loss of economy in distribution from points of supply to points of consumption, and suggestions for improvement.

2. The Low Temperature Distillation of Coal, showing what has been done and what is possible in reclaiming the byproducts of coal and lignite. A special point should be made of what the United States Government has done and what it may appropriately do in connection with individuals and industries in developing a more economic use of fuels by means of recovery.

3. Fuel Conservation vs. Money Conservation, showing how the monetary consideration interferes with fuel economy and how, frequently, fuel can be saved if expense did not have to be considered. If an enormous tax were placed on coal, the waste of coal would stop. A broad treatment of the subject of possible fuel saving by generating electricity at the mines is suggested. This is to be considered under two heads—where the distant consumer requires power alone, and where the distant consumer requires heat as well as power.

4. What Is the Effect of the Cost of Freight Per Ton of Coal on the Cost of a Kilowatt-Hour, as Against the Cost of Transmitting the Kilowatt-Hour from the Mines to the Point of Consumption, Including Transformation and Transmission Losses?

Profiteering of the Mines

A statement of unusual interest was issued by the Department of Justice on June 24. It follows in its entirety:

In connection with the recent instructions from Attorney General Palmer to all United States attorneys to procure indictment of soft-coal operators charging unreasonably high prices for coal, the following statement has been issued by the Department of Justice:

The instructions referred to were issued because of reports that soft coal was being sold at the mines at prices as high as from $7 to $11 per ton and in some instances even higher. The Lever Act, under which the indictments of offending operators are to be obtained, prohibits the taking of an *unreasonable* profit. An unreasonable profit results when the selling price unreasonably exceeds the cost of production. The cost of production cannot possibly justify the reported prices at the mines, as is shown by the following:

The production-cost figures gathered by the Federal Trade Commission from 1,589 bituminous-coal operators in the principal producing regions, mining roughly about 60 per cent of the annual output, show that during January, 1920, their costs per ton averaged $2.32 at the mines. Since then there has been an increase of 27 per cent in the cost of labor, enhancing the production cost $2.79 per ton. During the month of April, when the cost was $2.79 per ton, operators are reported to have sold their coal for between $3 and $4 per ton at the mines. Since then, as above stated, it is reported that their selling prices have been forced as high as from $7 to $11 per ton, and even higher.

Excuses offered for taking profits which are unreasonably high in comparison with the cost of production are not defense to the charge of profiteering—the purpose of the Lever Act was to prevent taking advantage of such excuses to mulct the public.

Moreover, the public should be advised that the claims of shortage of production, car shortage and export demands do not furnish any real excuse for the continuance of the high prices above referred to.

1. *Alleged Shortage of Production* — The production of soft coal for the first four months of the present year has exceeded the production for the corresponding period of any recent year excepting 1917 and 1918. To quote the report of the Geological Survey, the Governmental agency charged with the collection of compiling of such information, for the week ended May 15, 1920:

The production of bituminous for the first four months of 1920—173,574,000 tons—although smaller than in 1917 and 1918, exceeded both 1919 (138,936,000 tons) and the *pre-war years*.

2. *Car Shortage*—Service orders numbers 6 and 7 of the Interstate Commerce Commission, dated June 19, 1920, ought to result in an adequate supply of cars for coal for domestic consumption, if there has not heretofore been such a supply. Order No. 7 that, for thirty days beginning June 21, 1920, the railroads should furnish suitable cars to coal mines in preference to *any other use*, and should discontinue the use of coal cars for other commodities, thus giving the coal-mine operators full car service. Order No. 6 made rules for the railroads to follow after June 24, 1920, so as to give preference to the transportation of coal for *domestic* consumption.

By bearing in mind the foregoing points, and by refusing to be influenced by propaganda (which has appeared in certain quarters) into bidding against one another for coal at enormous prices (as is reported to have been done in some cases) consumers of soft coal can help to reduce prices to a reasonable level.

Canadian Association of Stationary Engineers' Convention

The thirty-first annual convention of the Canadian Associaton of Stationary Engineers was held at Woodstock, Ont., June 22, 23 and 24. The Oxford Hotel was the headquarters, and less than a block away was the Woodstock Market, the main floor of which was occupied by the Canadian Exhibitors' Association in the display of the latest mechanical devices and power-plant equipment. The executive sessions of the engineers were held in the City Hall, directly opposite to the exhibition building. The local committee are to be congratulated upon the unusual convenience of its arrangements.

There were upward of forty delegates in attendance. The principal feature brought before the body was a discussion on the advisability of amendments being made to the existing license laws, and the growing necessity for high-class engineers. The educational committees were urged to continue in the good work accomplished during the past year, and were advised to get into closer relationship with the Northwestern Association of Mechanical and Electrical Engineers of Edmonton. There were also warm discussions on proposed changes in the preamble.

The exhibition hall was open from 9 a.m. until 10 p.m., and considerable interest was manifested by the delegates and visitors in the display at the various booths.

On Tuesday evening there was an educational meeting and smoker. W. H. Auger read an interesting paper on "Parallel Lines," and Hartley B. Gardner created a general discussion on the reading of his instructive paper on "Combustion," the discussion being opened by A. M. Wilkins. An entertainment was furnished by Mr. Fletcher, of the Garlock Packing Co.; Bob Jones, of the France Packing Co., and Jack Armour, of *Power*.

On Wednesday afternoon the convention was entertained by the Exhibitors' Association at Southside Park. Outdoor sports of many kinds were indulged in, with prizes for the winners of each event. Refreshments were served at intervals during the afternoon.

On Wednesday evening an entertainment was held in the City Hall. Mayor A. J. Gahagan welcomed the convention to the city and acted as master of ceremonies, introducing the several entertainers. At the conclusion of the performance prizes were distributed and dancing followed.

John McCalley, president of the local association was the recipient of a silk umbrella, the gift of the supplymen.

The engineers elected officers as follows: George Moll, past president, London; R. C. Leach, president, Toronto; Fred Harper, vice president, Kingston; L. J. Ellis, secretary-treasurer, Hamilton; W. Fyfe, conductor, Montreal; R. E. Rodney, doorkeeper, Ottawa.

At the supplymen's meeting on Thursday morning the following officers were elected: Calvin B. Turner, president; Grant E. Cole, first vice president; Edward B. Curzon, second vice president; Gordon C. Keith, secretary; David M. Archibald, treasurer; Robert Jones, assistant treasurer.

Ottawa was selected as the next convention city in June, 1921.

Connecticut State N. A. S. E. Convention

The twenty-fifth Annual Convention of the National Asscciation of Stationary Enginers, Connecticut State Branch, Bristol Local, was held at Bristol, June 25-26.

The convention was opened Friday evening by President David A. Wilcox. The meeting was thrown open for informal discussion, which centered on the coal situation and the relative advantages of coal and fuel oil. The performance of various types of boilers and ways and means of changing from coal to oil as a fuel were discussed. At the close of the session, Jack Armour, of *Power*, furnished entertainment, which was very much enjoyed. On Saturday morning the second session of the convention was held at the Red Men's Hall. Routine business and reports of committees were heard and the session closed with the election of officers, which resulted as follows: B. M. Doyle, Waterbury, president; John Donahue, Hartford, vice president; Fred Sutorius, New Haven, secretary-treasurer; Harry J. Petit, Bristol, conductor; N. A. Cunningham, Waterbury, doorkeeper. David Wilcox, the retiring president, automatically became a trustee, superseding E. E. Thomas, of New Haven. Oscar A. Thomas of Bristol was elected State Deputy.

At the close of the morning session the members and delegates boarded a special car for Lake Compounce, a beautiful little lake, twenty minutes' ride from Bristol. Here the big time of the convention was staged. Dinner was served and swimming, boating and outdoor games were the order of the afternoon and evening. The next convention will be held on the last Friday and Saturday in June, 1921, at Hartford.

Navy Department Awards Fuel-Oil Contract

Awards for 5,200,000 bbl. of fuel oil as result of recent bids submitted are announced by the Navy Department.

To avoid further increasing the price of oil and gasoline by decreasing the amount of American oil available for commercial purposes, the Navy Department, in awarding its contract for the coming year's supply, by a slight modification of its standard specifications has been able to utilize a large amount of crude Mexican oil hitherto unavailable for naval purposes. In addition the Navy will receive as a byproduct in refining this oil for fuel use during the coming year, 16,792,000 gal. of gasoline, which will not only meet the Navy's full demand, but leave sufficient to relieve the needs of other Government departments to a considerable extent at a price of approximately the actual cost of manufacturing and transportation.

The department has also inserted a clause in the contract by which the company refining the oil for the Navy agrees to instruct specially detailed naval officers in every detail of manufacture and to give the Navy the use of any patented or secret processes should it later seem advisable to go into the refining business on its own account. In this way for the first time exact and accurate knowledge of the cost of fuel oil and gasoline will be ascertained, and in future years the Navy will be in possession of indisputable data as to what should be a proper cost for both oil and gasoline and will have the nucleus of a personnel to carry on research work of its own.

Waterbury Section A. S. M. E. Holds Annual Meeting

The annual meeting of the Waterbury Branch, Connecticut Section of the American Society of Mechanical Engineers, was held at beautiful Lake Quassapaug, Saturday, June 26. The members were the guests of William H. Bristol, Mr. Thompson and Frederick S. Chase at Mr. Bristol's cottage on the lake. The meeting was of an informal character, and baseball was enjoyed on the spacious lawns during the afternoon. A motor launch was also provided, and the visitors were given an opportunity of a sail around the lake. An outdoor dinner was followed by a short business meeting and election of officers.

Mr. Thompson was re-elected chairman, and E. O. Goss was made vice chairman, superseding Frederick S. Chase. The following were re-elected: treasurer, Howard Isbell; and secretary, John R. Putnam. A meeting committee was appointed as follows: Frederick S. Chase, chairman; William H. Bristol, D. Delancy, Edwin Sanderson, I. W. Day, Capt. George J. R. Sheldon and Roger Sperry.

After the meeting the members repaired to Mr. Bristol's country home in the suburbs of Waterbury via motor cars, and an invention of Mr. Bristol's was demonstrated; namely, the synchronization by electricity of a vocal selection on a phonograph with the music played by an electric organ. Following this interesting entertainment the members visited the Bristol Company's laboratory to view Mr. Bristol's talking moving pictures. The talking pictures, while developed to a point where successful demonstration is possible, are still in a rough stage and it will be some time before the invention will be put to commercial use for the entertainment of the public.

Natural Gas Production in the United States

The production of natural gas in the United States gradually increased from 1906 to 1917, but declined in 1918. The greatest producers, named in order of quantity produced, have been West Virginia, Pennsylvania, Oklahoma, Ohio, Kansas, California and New York.

An increase in the number of producing wells totaling 135 per cent from 1906 to 1918 is reported, and the area of developed natural-gas land has increased 177 per cent since that date. The total area in 1918 was about 14,500 acres.

The average annual consumption of natural gas for domestic use has been about one-third of the total consumption, and the average annual consumption for industrial use about two-thirds.

The total amount received for the two-thirds consumed for industrial use is smaller than that received for one-third consumed for domestic use, a fact that indicates that the industrial gas was sold at very low rates.

Over 2,500,000 domestic consumers and more than 201,000 industrial consumers now use natural gas, an increase since 1906 of 187 per cent in the domestic class and of 83 per cent in the industrial class.

To a large extent the industrial consumption reaches its maximum in summer and its minimum in winter, owing to the decrease of the domestic demand in summer, which leaves more gas available for industrial use.

The average annual domestic consumption per consumer from 1906 to 1918 was 105,000 cu.ft., and the average industrial consumption per consumer from 1906 to 1918 was 2,428,000 cubic feet.

The average price of domestic gas is between 30 and 40 cents a thousand cubic feet, that of industrial gas is between 15 and 20 cents.

About 76 per cent of the total natural gas consumed in the United States is not consumed in the states where it is produced, but is piped to other states.

The United States produces about 95 per cent of the natural gas produced in the world and thus has a monopoly of this resource, as Russia has a monopoly of platinum, Germany of potash, and Chile of nitrate.

Oils for Power Plants*

By C. B. Whitman†

Take a wine glass, dip your finger in water and as you rub it over the edge of the glass notice that the friction is pronounced; now wipe the finger dry and dip it in glycerin and again rub the glass—the friction is about the same. Dip the finger in lubricating oil and rub the glass. You find that the friction is almost imperceptible, which demonstrates that while glycerin has a viscocity far greater than the oil, its lubricating quality is lacking, because the surface tension of either water or glycerin is not strong enough to form a substantial film, even under very light loads, for they are both lacking in capillarity and in molecular attraction. For this reason many very viscous liquids fail to form a good lubricating film.

This also demonstrates that to be a good lubricant a liquid must have nearly as great a surface tension as a solid, also that its lubricating value depends on the thickness of the layer it forms when spread over the surface and the resistance it offers to the efforts of the load to expel it from between the solid surfaces.

Little is known about the properties of liquid films other than that which is obtained from the frictional data. The static friction of solid surfaces when lubricated with lard oil and sperm oil prove that the lard oil gives the lowest coefficient and therefore must form the thickest film. Experience teaches that when the superfluous oil has drained away the combined capillary and molecular attraction comes to the aid of the viscosity and increases the tensile strength which tends to prevent rupture.

Molecular and capillary attraction are possessed to a greater extent by mineral oils when properly refined, than by either animal or vegetable oils, but mineral oils are deficient in oiliness and will not keep the static friction as low as do animal or vegetable oils.

At speeds of 500 or more per min., under normal loads, and with bath lubrication, lard oil will sustain a film of only 0.005 in. thick, whereas a pure mineral oil of the proper viscosity will sustain a film of about 0.007 in. thick, which proves that for all ordinary machine bearings running under normal conditions, a mineral oil of the proper viscosity is a better lubricant by two-fifths than one of the best-known fixed oils. This has led to the blending and compounding of mineral oils. Blended oils are a mixture of mineral oil and fixed oils in proportions that will thoroughly neutralize; compounded oils are a mixture of mineral oil with metallic soaps of different kinds for the purpose of increasing the viscosity; experiment alone can tell as to the value of the mixture; often they are more detrimental than beneficial from a lubricating point of view.

As lubrication is of value only as its ability to reduce friction, we must consider the circumstances that influence friction. Cohesion is aggravated rather than diminished by efforts to produce smooth surfaces, for the more perfect the surface the greater will be the points of contact. At minute distances molecular attraction increases, which causes the surfaces to adhere and resist motion. For example, pieces of marble with polished surfaces will adhere when pressed together and their cohesion is so great that one piece when suspended will sustain the weight of the other. Again take two pieces of lead, scrape them clean and press them together in a vise and they will adhere almost as firmly as if they were one.

Of course the pressure to accomplish this is far greater than we get on a bearing, and I merely use these examples to show that there is cohesion between smooth surfaces. In a bearing the increased friction caused by motion generates heat, which increases the tendency of the surfaces to adhere, the area affected rapidly spreads and the surfaces seize or abrade each other. This happens in a "hot box."

The coefficient of friction of motion is the only one of interest from a lubricating point of view, and it is defined as that value which, when multiplied by the pressure normal to the surfaces in contact, gives the measure of the maximum frictional resistance to motion.

The value of viscosity and density of oils depends on the viscosity of the lubricant, the relative speed of the surfaces, their area and inclination to each other, thickness of the lubricating film. When these conditions are known, the resistance to the motion of any given body can be easily calculated.

To properly lubricate the different bearings found in modern practice, it is necessary for the lubricating engineer to know, first, the oiliness or greasiness of all lubricants, the frictional effects due to the viscosity of the lubricant, effects due to the different methods of application, the effects produced by different metals working in contact, the effects of temperature on friction and viscosity, and the effects due to different speeds under given loads. When the speed of the rubbing surfaces is less than ten feet per minute, the lubricant, instead of being forced between the surfaces and keeping them apart, is swept on under pressure, and the lubricant depends as much on its oiliness as on the viscosity.

Solid lubricants such as mica, graphite and soapstone have great carrying power at low speeds, but their value depends as much on the nature of the surfaces. Graphite, for instance, gives the best results when used on cast-iron surfaces, which are naturally very porous and hold the graphite, but the frictional loss and wear are great. Solid lubricants mixed with animal fats, greases, vaseline or rosin oil are suitable for low speeds and heavy loads, as they give a low coefficient and do not waste away rapidly by evaporation nor run off the bearings. Greases compounded from animal and vegetable fats, or mineral oils emulsified with water soap and alkali enough to neutralize them, are good lubricants for slow-moving bearings with excessive loads, provided the oils do not contain too much water and are not adulterated with foreign substances; the oil should not run down and leave the soap, which is liable to occur in poorly made greases.

Properties of Lubricating Oil for Low Speeds and Heavy Loads

In selecting an oil for low speeds and heavy loads, viscosity is the first guide, and next is oiliness. At speeds of 100 ft. per min., with proper application, as before stated, the oil forms a fairly thick film, and when the load does not exceed 250 lb. per sq.in., the formation of the film and the friction are wholly due to the viscosity; but at heavy loads the bearing surfaces are brought into contact at a point on one side of the bearing and the lubricant should possess oiliness to a greater degree to prevent seizing. In cases of flat surfaces, such as the guide on reciprocating engines, the viscosity is not quite so important as the oiliness; at loads of 75 lb. per sq.in. a blended lubricant is best.

For motors, generators, turbines and the crankcase type of high-speed engines, best results are had by using a straight mineral oil of the proper viscosity. For motors and generators with bath-ring oiling devices best results are obtained by using a pure mineral oil of a viscosity of from 120 to 198 (Saybolt) according to speed and load. Turbines having either forced or circulating lubrication should have a light oil for two reasons: First, because the lighter oils maintain their viscosity better at the relative high temperatures, and second, on account of the high speeds. It must also be an oil that will not emulsify and one that will readily separate from water, as there is leakage of steam in most turbines. The viscosity should not be less than 98, nor more than 120 at 100 deg. F.

For steam-cylinder lubrication there are four conditions met with in modern practice that form a guide in selecting a proper oil; namely, steam supersaturated, saturated, dry, and superheated. For a supersaturated condition the oil should be heavily blended with pure tallow to give good results; for a saturated condition a light blend of tallow and blown rape will give good results; for dry steam about 6 per cent blown rape gives good results, but for superheated steam one must have a pure steam-refined mineral oil, otherwise the intense heat will burn off the animal and vegetable oil, release the acids they contain and pit the cylinder walls.

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*From a paper read at Buffalo, N. Y.

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New Publications

PROCEEDINGS OF THE AMERICAN ELECTRIC RAILWAY ENGINEERING ASSOCIATION, 1919. Published by the Engineering Association, West Fortieth St., New York City. Cloth, 6 x 9¼ in.; 416 pages.

A number of interesting papers covering power distribution, supply, generation, etc., which were read at the 1919 convention at Atlantic City, are contained in the publication. A summary of previous proceedings of the association is given, together with an alphabetical list of papers that were presented at meetings since 1911.

DIESEL ENGINE DESIGN. By H. F. P. Purdy. Published by D. Van Nostrand Co., New York City. First edition; 295 pages; 271 illustrations.

As the author states in his preface, this volume was written for the Diesel-engine designer. It contains much useful and heretofore unavailable data. Chapters 1 to 3 are devoted to the thermodynamics involved. Chapter 4 takes up the theory of similitude which, apparently, is not generally observed by the designer. The remainder of the volume covers the design of the various engine parts; the chapters devoted to crankshafts, connecting rods and pistons are especially meritorious. It is unfortunate that the subject of fuel systems is dismissed with so little discussion. The fuel pump and injection valve are the most important parts of the engine, and it is somewhat surprising to find practically no information offered. The book as a whole is remarkably well written and should be of interest both to the designer and to the operating engineer.

MILLWRIGHTING. Published by McGraw-Hill Book Co., Inc., 239 West 39th St., New York City. Second edition. Cloth, 6 x 9 in.; 454 pages, 158 illustrations.

Several changes and corrections have been made from the former edition, with the addition of a chapter on the installation of electric motors and methods of adapting millwright practice to the changed conditions of recent years. The book is intended as a guide to the modern millwright, who is expected to execute the more or less perfect plans of the consulting engineer and, in many instances, provide the details and supply most, if not all, of the minor engineering of factory location, laying out and erecting buildings, provision for foundations and supports for machinery, framing, laying out shafting, belts, steam and waterpipe fitting, erection of engines, setting of boilers, installation of waterwheels, and erection, connection and care of electric motors. While the work is primarily addressed to engineers engaged in new mill contruction, it will be found of especial value to operating engineers, master mechanics and consulting engineers who are interested in practical operations required for extension, alteration or maintenance of industrial plants and installation of their mechanical equipment.

Personals

B. V. E. Nordberg has been appointed sales manager of the Nordberg Manufacturing Co., Milwaukee, Wis.

H. W. Dow, formerly sales manager, recently resigned to become vice president and engineer of the Forest Products Chemical Co., Memphis, Tenn.

Charles E. Prout, Jr., has become advertising manager of Gillis & Geoghegan, West Broadway, New York City, manufacturers of telescopic hoists. He was formerly connected with the Ingersoll Watch Company.

C. T. Stiles, formerly first lieutenant, Engineering Division, Ordnance Department, has joined the Mechanical Goods Division of the United States Rubber Co., being located at their Philadelphia office.

Edward Caldwell, treasurer of the McGraw-Hill Co., Inc. publishers of *Power*, and the Mc-Graw-Hill Book Co., was tendered a dinner by his business associates celebrating his thirty years' service with the McGraw interests.

Alois Hauser has been appointed assistant to the works manager in charge of engineering, of the Timken Roller Bearing Co., Canton, Ohio. For the past several years, Mr. Hauser has been efficiency engineer at the Saucon plant of the Bethlehem Steel Company.

Commander R. D. Gatewood, of the Construction Corps, U. S. Navy, has been selected by Chairman Benson as Director of Construction and Repair of the Emergency Fleet Corporation, relieving R. L. Hague, of San Francisco. During the war Commander Gatewood was superintendent of motive power for the Panama Railroad in charge of the large shops and drydocks at both ends of the Isthmus and made an enviable record in connection with extensive repair and refitting work on merchant vessels.

Society Affairs

The American Peat Society's annual meeting, which will be held at Madison, Wis., has been advanced to Sept. 2, 3 and 4.

The American Society of Mechanical Engineers, Connecticut Section, Bridgeport Branch, will hold a shore outing, on Friday afternoon, July 16, at the Momauguin, just east of New Haven. Field sports, bathing and dancing have been arranged for the amusement of the members. The annual election of officers will be held by letter ballot.

Engineering Council at its meeting on June 17 indorsed the plan of the organization of the Federated Engineering Societies and the American Engineering Council, adopted by the organizing conference of technical societies in Washington June 3 and 4, and authorized its executive committee to render such assistance as was practicable in completing the work of the Organizing Conference and of the Joint Conference Committee of the Founder Societies in establishing the American Engineering Council.

Additions to Standards Committee—Five additional bodies have been admitted to representation on the Main Committee of the American Engineering Standards Committee. They are: Electrical Manufacturers Council (Electric Power Club, Associated Manufacturers of Electrical Supplies, Electrical Manufacturers Club); Fire Protection Group (National Fire Protection Association, National Board of Fire Underwriters, Associated Factory Mutual Fire Insurance Companies, Underwriters Laboratories); National Electric Light Association; National Safety Council; Society of Automotive Engineers. These, with the five engineering societies who founded the committee (American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers, American Society for Testing Materials), and the three Government departments, added later (Commerce, Navy and War), make a total of thirteen organizations having representation on the Main Committee.

Business Items

The Goetze Gasket and Packing Co., New Brunswick, N. J., announces the opening of new branch offices in New York City at 242 Lafayette St. The new offices will include sales and stock rooms.

The Carborundum Co., Niagara Falls, N. Y., recently acquired from the Alien Property Custodian the plant formerly owned and operated by the Didier-March Co., at Perth Amboy, N. J. This will be taken over at once and converted to the manufacture of a complete line of carborundum refractories.

The Board of Directors of the SKF Industries, Inc., at a special meeting held May 13, accepted the resignation of B. G. Prytz, as president, Mr. Prytz having been elected managing director of the parent company, with headquarters at Gothemberg, Sweden. At the same meeting F. B. Kirkbride, vice president since the organization of the company, was elected president to succeed Mr. Prytz.

The Economy Fuse and Manufacturing Co., of Chicago, manufacturers of Economy renewable fuses, announces the appointment of F. L. Easton as district sales manager of its Denver office, 205 Commonwealth Building. Mr. Easton succeeds R. M. Olsen, who resigned recently. Mr. Easton formerly was connected with the Economy Fuse and Manufacturing Co., but more recently has been doing sales promotion work for the Gates Rubber Co.

The Freeman-Riff Co. is just completing its new plant at Terre Haute, Ind. The company manufactures conveying machinery, specializing in the design, manufacture and installation of complete conveyor installations, particularly for the handling of coal in boiler plants and retail coal pockets. J. B. Freeman, the president of the company, will be in direct charge of plant operation and production.

Midstates Engineering Company, Westminster Building, Chicago, has recently incorporated as consultants, specializing in industrial, power and plant engineering. The equipment and commercial division activities will be directed by J. H. Milliken, who is well known in this field as an industrial sales manager. The engineering work will be executed by R. J. Gaudy, president, who is widely known through his activities with the Sessions Engineering Co., and his connection with many notable engineering projects.

The Chicago Pneumatic Tool Co., New York, announces the election of Allan E. Goodhue as vice president in charge of sales. Mr. Goodhue since May 1, 1919, has been managing director of the company's English subsidiary, the Consolidated Pneumatic Tool Co., London; also director of European sales for the Chicago Pneumatic Tool Co. Mr. Goodhue was formerly connected with the sales department of the Midvale Steel Co. and Midvale Steel and Ordnance Co., in Philadelphia, Chicago and Boston.

The Westinghouse Electric International Co. has made several changes in the personnel of the company. At East Pittsburgh they are as follows: H. F. Griffith, assistant to general manager; R. W. Everson, manager of merchandising department; H. C. Soule, manager apparatus department; and H. S. Reizenstein, manager price department. In New York they are: G. H. Butcher, assistant to general manager; J. H. Payne, supervisor of agencies; and F. M. Sammis, manager of incandescent lamp department. A. B. Cole, assistant manager, department of publicity, Westinghouse Electric and Manufacturing Co., has been placed in charge of the advertising and promotion work for the Westinghouse International Company.

Trade Catalogs

The Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., has ready for distribution a new 24-page catalog, No. 5-A-1, describing the Westinghouse line of insulating materials and supplies. A copy will be sent on request.

"Shuveloder, The Mechanical Mucker," is the title of a new 15-page catalog now ready for distribution by the Lake Superior Loader Co., Duluth, Minn. Descriptions and photographs of the various types of mucking machines handled by the company are given.

The Pennsylvania Pump and Compressor Co., Easton, Pa., has issued a new 12-page pamphlet entitled "Pennsylvania Air Compressors." Class 3A, single stage, belt drive are shown, together with charts showing size of cylinders (diameter and stroke), revolutions per minute, air pressure, cubic feet free air per minute, etc. A copy will be sent on request.

"W.S.M. Hydraulic Turbines" is the title of a new 88-page catalog just issued by the Wellman-Seaver-Morgan Co., Cleveland, Ohio. Illustrations and blueprints of turbines, horizontal or vertical units with spiral casings of cast steel, cast iron or steel plate are shown, also vertical units with concrete spiral casings or open flumes equipped with cast steel, cast iron or bronze runners are described.

The Traylor Engineering and Manufacturing Co., Allentown, Pa., has ready for distribution a new 50-page bulletin, No. 101, entitled "The Superpump and Hydraulic Machinery." The bulletin contains a comprehensive description of the constructional details of the Traylor superpump. Contained in the booklet is subject matter which should prove of practical value to the operating engineer and will also give the purchaser data of value. A copy will be sent on request.

George B. Carpenter & Co., manufacturers and distributors, of Chicago, are issuing catalog No. 110, 1920 edition, containing 1,088 pages, devoted to equipment and supplies for railroads, steamships, contractors, mills, mines, power plants, machine shops and all forms of industrial activity. The power-plant list is quite diversified, including such items as return-tubular boilers, boiler tubes, grates, motors, pipe fittings, valves, pipe hangers, pumps, gages, lubricators, oil filters, force feed oil pumps, oil cups, etc. As an illustrated reference for equipment and supplies, the catalog should prove of great value to the engineer.

Coal Scarce and Expensive

Little improvement is to be noted over last week. Lack of cars is still the predominant inconvenience. The coal shortage is most acute in the bituminous market.

New York—The present unrest in the anthracite market is attributed to a shortage of bituminous rather than an anthracite coal, but conditions are no better than last week. Nearly all producers complain of lack of cars, which lack has the effect not only of preventing adequate distribution but of causing restlessness among the workers as well. The larger dealers are frequently without one or another of the larger sizes. There was an active market last week for steam sizes although no heavy tonnages were available. Independent buckwheat was quoted at from $4.25 to $4.75; rice $3.25 to $3.75 and barley around $2, all at the mines. The prices of company coal per gross ton at the mine are $4 to $4.10 for buckwheat, $3 to $3.50 for rice and $2.25 to $2.50 for barley.

Considerable uneasiness has developed in the bituminous market because of agitation by the press. Numerous conferences with the Interstate Commerce Commission brought about an understanding that the situation would be taken care of even if it were necessary to issue priority orders.

Philadelphia—The anthracite trade has been crippled by an outlaw strike of freight crews that occurred suddenly on the railroads entering this city, on June 19, resulting in an embargo on anthracite which has not yet been raised. There is a most urgent demand for all sizes of steam coal with buckwheat in the lead. The railroads have endeavored to move steam sizes to the essential industries which are running on an extremely close margin.

The bituminous situation is even more serious than the anthracite, with very little tonnage entering the city. Some sales have been made as high as $13 a ton at the mine, although for the most part prices have been closer to $11.

Chicago—During the week the railroads serving Chicago placed a number of embargoes. It is said that neither Indiana nor Illinois coal can enter Michigan until further notice. The market is uniformly strong with several advances.

Pittsburgh—The effect of embargoes against the East has decreased bidding by export buyers. The recent high prices for the Pittsburgh district have been due largely to wild bidding by these buyers. It is stated that a relatively small further increase in car supplies would ease the market greatly. Steam coal is now quoted at $7.50 to $8.50 spot at the mine.

Buffalo—The bituminous situation has not improved, but has actually grown more serious, with transportation the main difficulty. It is stated that if the car supplies were increased 50 per cent the $10 maximum prices for coal would decrease to $4. Under the circumstances there is no settled price.

There is a heavy demand for anthracite from Canada, but Canadian dealers are having difficulty in obtaining coal. Last week the Lake movement amounted to 124,800 net tons of which 38,600 cleared for Chicago, 30,800 for Duluth Superior, 29,900 tons for Milwaukee, 11,500 tons for Port William, 7,500 tons for Ashland and 6,500 tons for Sheboygan.

St. Louis—Many plants are hard pushed for steam sizes in St. Louis. Buyers from Chicago and Northern cities are in St. Louis in large numbers and are offering fancy prices. Standard is moving North at $5 to $5.50 for all sizes. In the Mount Olive field prices are about $3 to $3.75 for all sizes, the regular trade being given preference. The mines work on commercial coal from one to one and a half days a week, while the railroad mines get four to five days. Practically no anthracite, smokeless or Arkansas fuel is coming into St. Louis.

Boston—The Interstate Commerce Division issued an order effective June 24 calling for priority for cars bearing coal via Tidewater for New England points for the relief of the railroads and industries in that section. The market is extremely active for spot coal. In the main there is a distinct gain in the time necessary for moving cars.

New Construction

PROPOSED WORK

Mass., Belchertown—The Committee on Mental Diseases, 36 State House, Boston, will soon award the contract for a 2 story, 90 x 117 ft. dormitory, etc., including a steam heating system, for the Commonwealth of Massachusetts. About $250,000. Kendall, Taylor & Co., 93 Federal St., Boston, Archts. and Engrs.

Mass., Boston—The School House Comn. received bids for installing new boilers and other changes from J. P. Dwyer, 80 Boyl St., $7,588; Pearse & Cox, $7,687; J. J. Hurley & Co., 104 B'way., $7,754. Noted June 29.

N. Y., Dannemora—Charles F. Rattigan, Supt. of the State Prisons, Capitol, Albany, will soon award the contract for a refrigeration plant and cooling rooms in the kitchen building at the Clinton Prison here. One refrigerating machine, brim coils, etc., will be installed in same.

N. Y., Iroquois—W. S. Lawton, Pres. of the Bd. of Mgrs., will soon award the contract for additions and equipment for the water supply system including a deep well and pumping apparatus consisting of a new motor, well cylinder and well pipe, 10 hp. motor at the Thomas Indian School, here.

N. Y., Lockport—The Lockport Boiler & Welding Works, 237 Market St., is in the market for one 30 hp. vertical or locomotive type boiler.

N. Y., Schenectady—D. J. Bondy, 82 Wall St., New York City, plans to build 2 theatres including a steam heating system. About $600,000. DeRosa & Pereira, 110 West 40th St., New York City, Archts. and Engrs.

N. J., Cape May—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., received bids for repairing the power house equipment at the United States Naval Section Base, here, from the B. E. Eng. Co., 22 Leight St., New York City, $5,482; George S. Curtis, $3,552; Frank J. Eisinger, 141 7th Ave., Brooklyn, $4,281.

N. J., Trenton—The City Comn. will receive bids until July 23 for a 10,000,000 gal. triple expansion vertical type, E. P. Allis steam pump. J. R. Fell, Engr.

N. J., Trenton—The State received only bid for the installation of a heating system in the proposed 4 story, 50 x 300 ft. capitol building on West State St., from W. G. Royer, 167 Rosemont Ave., $17,406.

Pa., Blairsville—The Western State Hospital for the Insane plans to build a power house, ward buildings, etc., in connection with the Farm Colony 1 at Torrance near here.

Pa., Charleroi—The First Natl. Bank of Charleroi is having plans prepared for altering the present bank building including a steam heating system. About $500,000. W. L. Stoddart, 9 East 40th St., New York City, Archt. and Engr.

Pa., Elmhurst—The St. Nicholas Greek Catholic Church of America plans to build a 3 story, 100 x 250 ft. orphanage, including a steam heating system, on Elmhurst Ave. About $300,000.

Pa., Erie—The Second Natl. Bank, 8th and State Sts., will soon award the contract for a 1 story, 60 x 130 ft. bank including a steam heating system on 9th St. About $400,000. W. L. Stoddart, 9 East 40th St., New York City, Engr.

Pa., Philadelphia—The Stanley Co. of America, 1214 Market St., is having plans prepared for a 16 story theatre including a steam heating system on Market and 11th Sts. About $1,000,000. Hoffman & Henon, Finance Bldg., Archts.

Pa., St. Marys—F. Arthur Rianhart, Archt., Masonic Temple, Williamsport, will receive bids until July 26 for converting monastery into a hospital and building a power house for the Andrew Kaul Memorial Hospital here. Separate bids for heating, electrical and plumbing work will be received. About $100,000. Sedgwick Kistler, Pres.

Pa., Uniontown—Albert Kahn, Archt., Marquette Bldg., Detroit, will soon award the contract for a 9 story, 38 x 56 ft. mercantile building including a steam boiler, etc., for heating system, on Gallatin Ave. and Main St., for the Aaron Furniture Co.

Md., Baltimore—The city is having plans prepared for a 3 story, 100 x 500 ft. high school including a steam heating system on Poplar Grove St. About $600,000. Edward H. Glidden, Amer. Bldg., Archt.

Md., Baltimore—Samuel T. Williams, 223 North Calvert St., is in the market for a duplex, compound, belt-driven air compressor, 270 to 400 cu.ft. of free air permitted to 100 lb. pressure (used).

S. C., Paris Island—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., received bids for improvements to power plant at the Marine Barracks here from Noland Clifford, 330 28th St., Newport News, Va., (1) work complete, $49,452. (2) deduct $2,000. (3) $5,000. Noted June 15.

Fla., Jacksonville—The city is having plans prepared for remodeling the Home for the Aged and installing laundry equipment, heating system, etc., in same. About $50,000. J. H. Lynch & Son, Dolph Bldg., Archts. and Engrs.

O., Akron—The Akron Prospect Co. plans to construct a hotel and theatre building, including a steam heating system. About $1,250,000. John Eberson, 64 East Van Buren St., Chicago, Archt.

O., Canton—The Bd. Educ. plans to build a 2 story grade school, including a steam heating system. About $250,000. C. Lane, Clk. Thayer & Johnson, 5716 Euclid Ave., Cleveland, Archts.

O., Euclid—The Sisters of the Good Shepherd, East 30th St. and Carnegie Ave., Cleveland, has purchased a site at Stop 10½ Euclid Ave., and plans to build a 3 story convent and school including a steam heating system on same. About $300,000. Address Mother Berdanars.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., plans to construct a 1 story school on Howard and East 146th St., a 3 story school on Parkview and Mt. Auburn Sts. and a 1 story school on East Woodland and East 128th St. Steam heating systems will be installed in same. About $2,750,000. W. R. McCormack, Archt.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., plans to build a 3 story school on East 175th St. near St. Clair Ave. and one on East 145th St. and Castalia Ave. Steam heating systems will be installed in same. About $750,000 each. W. R. McCormack, Archt.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., plans to build a 3 story junior high school at Woodland Hills Park, East 116th St. and Corlett Ave., Holmes Ave. and on Hyde Ave. and West 44th St. Steam heating systems will be installed in same. About $2,000,000 each. W. R. McCormack, Archt.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., received bids for the installation of a steam heating system in the proposed 1 story, 212 x 212 ft. school on East 92nd St. and Parkgate Ave., from J. Roemer Heating Co., East 22nd St., $163,127. Noted May 18.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., plans to construct a 1 story school including a steam heating system on Sandusky Ave. About $1,000,000. F. G. Hogan, Dir., W. R. McCormack, Archt.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., plans to construct a 1 story school including a steam heating system on Lake Ave. About $500,000. F. G. Hogan, Dir., W. R. McCormack, Archt.

O., Cleveland—B. Lederman, 10709 Pasadena Ave., is having plans prepared for a 6 story, 60 x 200 ft. hotel including a steam heating system on East 105th St. and Euclid Ave. About $500,000. M. Weiss, 618 Union Bldg., Archt.

Ind., West Hammond—R. G. Pierce, Archt., 10 South La Salle St., Chicago, will soon award the contract for a 1 story, 210 x 560 ft. steel plant including a steam heating system, for the La Salle Iron Works, 2305 South Halsted St., Chicago.

Mich., Bay City—The Wildman Rubber Co. is having plans prepared for a 1 and 3 story rubber manufacturing plant including a steam heating system. About $2,000,000. W. W. Wildman, Brook Bldg., Detroit, Pres. Osborn Eng. Co., 2848 Prospect Ave., Cleveland, O., Archt. and Engr.

Mich., Detroit—The Standard Reamer & Tool Co., Elmwood Ave. and Hendric St., will soon award the contract for a 1 story, 50 x 100 ft. tool factory including a steam heating system and motors for power on Elmwood Ave. About $15,000. Pollmar & Roper, 45 State St., Archts.

Mich., Saginaw—The Second Natl. Bank, 110 North Washington St., had plans prepared for a 16 story, 120 x 120 ft. bank and office building including a steam heating system. About $2,250,000. Weary & Alford, 1732 South Michigan Ave., Chicago, Archts.

Ill., Chicago—The Standard Oil Co. of Indiana, 910 South Michigan Ave., had plans prepared for a 9 story, 133 x 238 ft. addition to office building including a steam heating system. About $1,250,000. Marshall & Fox, 721 North Michigan Ave., Archts.

Ill., Chicago—John F. Talke Co., 759 South Washtenaw Ave., is having plans prepared for a 2 story, 112 x 120 ft. office building and garage including a steam heating system on Washtenaw Ave. and Polk St. About $600,000. Graham, Anderson, Probst & White, 1417 Ry. Exch. Bldg., Archts.

Ill., Evanston—The Glenview Golf Club is having preliminary plans prepared for a 1½ story clubhouse including a steam heating system. About $200,000. Holabird & Roche, 104 South Michigan Ave., Chicago, Archts.

Wis., Appleton—St. Elizabeth Hospital is having plans prepared for a 4 story hospital including a steam heating system. About $500,000. V. J. Klutho, Syndicate Trust Bldg., St. Louis, Mo., Archt.

Wis., Iron River—T. H. Okerstrom, Port Wing, is having preliminary plans prepared for a dam and power plant here. J. C. Jacobson, 533 Metropolitan Bank Bldg., Minneapolis, Minn., Engr.

Wis., Two Rivers—The Bd. Educ. will receive bids about Aug. 15 for a 3 story, 144 x 198 ft. high school, including a steam or vapor heating system or both. About $400,000. John Chubb, Dearborn St., Chicago, Archt.

Minn., Pipestone—S. W. Funk, Clerk, will receive bids until July 15 for a waterworks system including a water tower, 150,000 gal. tank, a 500,000 gal. capacity reservoir and a pumping plant for the city. About $550,000. L. P. Wolff, 1000 Guardian Life Bldg., St. Paul, Engr.

Mo., St. Paul—J. A. Wetmore, Supervising Archt., Treasury Dept., Wash., D. C., will receive bids until July 16 for repairing the boiler plant at the United States Marine Hospital here.

Tex., Breckenridge—The Guaranty State Bank is having plans prepared for a 5 or 7 story, 100 x 150 ft. bank including a steam heating system on Walker St. About $250,000.

Tex., Dallas—The Dallas Brass Mfg. Co., 1101 Ross Ave., is in the market for one 5 hp., 220 volt, a.c. motor, etc. (used).

Tex., Port Arthur—J. A. Wetmore, Supervising Archt., Treasury Dept., Wash., D. C., received only bid for installing a boiler from William Wilby, Selma, Ala., $2,595.

Wash., Puget Sound—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., received bids for the installation of auxiliary equipment and piping for the air compressor, from the Carroll Electric Co., 714 12th St., Wash., D. C., $49,800; Charles C. Moore & Co., Sheldon Bldg., San Francisco, Cal., $59,861. Noted June 1.

Que., Shawinigan Falls—The Shawinigan Water & Power Co. plans to issue $4,000,000 bonds to be used for expansion and improvements, including the construction of a second transmission line from here to Montreal and the installation of a new 50,000 hp. unit at the local plant.

Ont., Alexander—The town plans to install a local electrically driven pumping plant. The Hydro Electric Power Comn. of Ontario will furnish the energy. Major Palmer, Mgr.

Ont., Kingston—The Dominion Government has voted $265,000 bonds to construct a 3 story addition including a steam heating system, to the Royal Military College here.

Ont., Kitchener—The Lasky Film Corp., King St., plans to build a 1 story motion picture theatre including a vacuum steam heating and mechanical ventilating system, etc. About $350,000.

Ont., Toronto—The Ontario Hydro Electric Power Comn. plans to purchase the Niagara, St. Catharine and Toronto Ry., the Toronto Suburban Ry. and the Eastern Ry. and to make extension to the properties.

CONTRACTS AWARDED

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York City, has awarded the contract for a school on River Blvd. and 86th St., including a steam heating system, to James McArthur & Co., 22 Ormond Pl. About $650,000.

N. Y., Jamestown—The city has awarded the contract for furnishing and installing a heating plant in the Jones General Hospital here, to the Warren Constr. Co., at $15,800. Noted April 27.

N. Y., New York—The Bd. of Estimate, Municipal Bldg., has awarded the contract for a court house including a steam heating system on Center, Worth, Baxter and Pearl Sts., to Rodgers & Hagerty, Inc., 103 East 125th St., at $2,000,000.

N. Y., New York—The Federal Reserve Bank, 15 Nassau St., has awarded the contract for a 63 x 72 ft. storage building including a steam heating system, on Maiden Lane and Gold St., to M. Eidlitz, 30 East 42nd St., at $350,000.

N. Y., Olean—The Bd. Educ., Union Free School Dist. 1, has awarded the contract for installing a heating system in the school buildings Nos. 1, 2, 3, 4 and 7, to the Power Efficiency Corps, White Bldg., Buffalo, at $148,201. Noted June 15.

N. J., Lakehurst—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., has awarded the contract for a power house building and quarters shop at the Naval Air Station here, to the Hughes Foulkrod Co., Commonwealth Trust Bldg., Philadelphia, Pa., at $477,000. Noted March 30.

N. J., Lakehurst—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., has awarded the contract for installing power plant equipment at the Naval Air Station here, to the Lord Electric Co., 105 West 40th St., New York City, at $391,205. Noted June 8.

N. J., Morristown—The Manhattan Rubber Co., Willett St., Passaic, has awarded the contract for a plant including a steam heating system, to Stone & Webster, 170 B'way, New York City, at $1,000,000.

Pa., Harrisburg—The State has awarded the contract for a 3 story, 100 x 500 ft. office building including a steam heating system, to S. W. Shoemaker, 1545 North 6th St., at $684,000.

O., Cleveland—The Cleveland Electric Illuminating Co., 75 Public Sq., has awarded the contract for a 1 story, 45 x 70 ft. power house addition on West 65th St. and Madison Ave., to F. Hauselman, 408 Illuminating Bldg., at $75,000.

O., Cleveland—I. Margolin, 10527 Churchill Ave., will build an 8 story, 45 x 220 ft. hotel, including a steam heating system on the East Blvd. About $1,500,000. Work will be done by day labor.

O., East Cleveland (Cleveland P. O.)—The Natl. Lamp Co., Nela Park, has awarded the contract for a 1 story, 48 x 86 ft. heating plant at Nela Park, to the Heller Bros., East 152nd St. and St. Clair Ave., Cleveland. About $75,000.

Wis., Manitowoc—George Bros. Co., 913 South 8th St., has awarded the contract for a 1 story, 115 x 130 ft. theatre including a steam heating system on 58th St., to the Badger State Constr. Co., c/o A. V. Lill, 1415 Washington St. About $300,000.

Wis., Wauwatosa—The Milwaukee Co. Bd. of Administrators has awarded the contract for intercepting sewers and force main, to Brogan & Burns, 700 Donsman St., Green Bay, at $13,989, and for pumping station to Brill & Tanghe, 86 Michigan St., Milwaukee, at $1,790. Noted June 15.

Minn., Minneapolis—The Bd. Educ. has awarded the contract for installing a steam heating system in the proposed 2 story, 75 x 220 ft. Miles Standish School on 22nd Ave., South, to H. Kelley & Co., 925 Plymouth Bldg., $30,135; and in the Minnehaha School on 31st St. and 29th Ave., from Bjorkman Bros., 712 South 10th St., $29,025. Noted April 13 and March 30.

Mo., St. Louis—The Blanton Oleomargarine Co., 1st and Spruce Sts., has awarded the contract for a 5 story, 72 x 151 ft. power plant and industrial building, to the Kellerman Constr. Co., International Life Bldg., at $300,000.

Mo., St. Louis—The Bd. Educ., 911 Locust St., has awarded the contract for a 2 story, 132 x 175 ft. school, including a low pressure steam heating system at 226 South Euclid Ave., to the Kellerman Constr. Co., International Life Bldg., at $312,000.

Tex., Dallas—The Breckenridge City Waterworks Co. has awarded the contract for installing a distributing system, pump equipment, stand pipe, etc., in connection with the proposed dam across the Clear Fork of the Brazoo River, to John W. Moore, Breckenridge, at $350,000

Cal., Colton—The Pacific Fruit Express Co., 65 Market St., San Francisco, has awarded the contract for ice plant equipment including steel tanks, coils, air blowers, motors, etc., to C. M. Gay & Son, 2650 Santa Fe Ave., Los Angeles, at $42,056.

Cal., Los Angeles—The Pacific Fruit Express Co., 65 Market St., San Francisco, has awarded the contract for ice plant, equipment here, including steel tanks, coils, motors, etc., to C. M. Gay & Son, 2650 Santa Fe Ave., at $30,300.

Cal., Los Angeles—The Robertson Cole Studios, Inc., Currier Bldg., has awarded the contract for a moving picture studio including a power plant, on Gower St. and Melrose Ave., to the Milwaukee Bldg. Co., 403 South Hill St., Los Angeles. About $100,000.

Cal., Roseville—The Pacific Fruit Express Co., 65 Market St., San Francisco, has awarded the contract for ice plant equipment here including steel tanks, air blowers, coils, motors, etc., to C. M. Gay & Son, 2650 Santa Fe Ave., Los Angeles, at $35,173.

Ont., Leamington—The Bd. Educ. has awarded the general contract for a 2 story school, to John Burroughs, Windsor, at $88,290. A steam heating system with electrical motor and blower for mechanical ventilation will be installed in the same, cost, $17,224.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		85c. per ft.
Common, 2½-in.		30%

	Air		
	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.60	$0.40	$0.30

Steam—Discounts from List

First grade..... 20% Second grade..... 30% Third grade....45%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 50% Best grade..... 20%
Standard..... 30–10%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz. rolls):

Light Grade	Medium Grade	Heavy Grade
30%	25%	20%

RAWHIDE LACING { For cut, best grade, 25%, 2nd grade, 30%. For laces in sides, best, 79c per sq. ft.; 2nd, 75c. Semi-tanned: cut, 20%; sides, 83c per sq. ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$1.00
Asbestos for high-pressure steam	1.70
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.70
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.50
Rubber sheet	.50
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ¼- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are part of standard lists, with discounts.

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... List

For low-pressure heating and return lines { 4-ply..... 50% off; 3-ply..... 52½% off; 2-ply..... 54% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Chicago	St. Louis	Birmingham
Cup	8½	6.6	8½@ 9½	8½
Fiber or sponge	8½	8.6	8½@ 9½	8½
Transmission	10	8.1	12@14	8½
Axle	...	4.8	5½@ 6½	5½
Gear	6½	6.1	6½@ 6½	8½
Car journal	12(gal.)	4 7	8½@9½	4½

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
White	11.00@15.50	13.00	16.00	11.00 to 14.00
Colored mixed	7.00@10.50	9.00 to 12.00	12.00	9.50 to 12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$55.00	$6 00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York		Chicago	
	Current	One Year Ago	Current	One Year Ago
Raw in barrels (5 bbl. lots)	$1.63	$1.90	$2.02	$2.10
5-gal. cans	1.65*	2.03	2.27	2.30

*To this *oil* price must be added the cost of the cans (returnable), which is $2.25 for a case of six.

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current Dry and In Oil	1 Yr. Ago Dry and In Oil
	Dry	In Oil	Dry	In Oil		
100-lb. keg	15.50	17.00	13.00	14.50	15.50	13.00
25- and 50-lb. kegs	15.75	17 25	13.25	14.75	15.75	13.25
12½-lb. keg	16.00	17.50	13 50	15 00	16.00	13.50
1-lb. cans	18.50	20.00	15.00	16.50	15.00	15.00
5-lb. cans	20.50	22 00	16.00	17.50	16.00	16.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	30%	30%	30%
Tinned	30%	30%	30%

Boiler rivets, ½, ⅝, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York.....$6.00 Chicago.....$5.62 Pittsburgh.....$4 72

Structual rivets, same sizes:

New York.....$7.10 Chicago.....$5.72 Pittsburgh.....$4 82

REFRACTORIES—Following prices are f. o. b. works,

Bauxite brick, 56% alumina, f.o.b. Pittsburgh	M.	$145	
Chrome brick, f.o.b. Chester, Pa., carlots	net ton	90–	100
Chrome brick, 9 in. strs. and sizes, f.o.b. Baltimore	net ton	80–	90
Fire clay brick, 1st quality, 9 in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	M.	45–	53
Fire clay brick, 1st quality, f.o.b. St. Louis	M.	45–	...
Fire clay brick, 1st quality, f.o.b. New Jersey	M.	75–	...
Fire clay brick, 2d quality, 9 in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	M.	40–	...
Magnesite brick, 9 in. straights, f.o.b. Baltimore	net ton	90–	...
Magnesite brick, 9 in. sizes and shapes larger than 9 in.		Regular extras	
Magnesite brick, f.o.b. Chester	net ton	90 -	100
Silica brick, 9 in. and 9 in. sizes, f.o.b. works, Chicago district	M.	55–	...
Silica brick, f.o.b. Birmingham	M.	51–	55
Silica brick, f.o.b. Mt. Union, Pa	M.	50–	55

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	90.00	87.00	74 50	79.00	60.00	75.00
Commercial	50.00	42 00	21.50	17.50	15.00	15.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$20.00	$25.50–30.00
Cleveland	20.00	20.00
Chicago	21.00	16.50

In coils an advance of 50c. usually is charged.
Domestic iron (Swedish analysis) is selling at 12c. per lb.

SHEETS—Quotations are in cents per pound in various cities from warehouse; also the base quotations from mill:

	Large Mill Lots	New York			
Blue Annealed	Pittsburgh	Current	One Year Ago	Cleveland	Chicago
No. 10	3.55–6.00	7.12@8.00	4.57	7.55	7.02
No. 12	3.60–6.05	7.17@8.05	4.62	7.65	7.07
No. 14	3.65–6.10	7.22@8.10	4.67	7.70	7.12
No. 16	3.75–6.20	7.32@8.20	4.77	7.80	7.22
Black					
Nos. 18 and 20	4.15–6.30	8.50@9.50	5.30	8.20	7.80
Nos. 22 and 24	4.20–6.35	8.55@9.55	5.35	8.25	7.85
No. 26	4.25–6.40	8.60@9.60	5.40	8.30	7.90
No. 28	4.35–6.50	8.70@9.70	5.50	8.40	8.00
Galvanized					
No. 10	4.70–7.50	9.75@11.00	5.50	8.50	8.15
No. 12	4.80–7.60	9.85@11.00	5.55	8.60	8.20
No. 14	4.80–7.60	9.85@11.10	5.50	8.60	8.35
Nos. 18 and 20	5.10–7.90	10.10@11.40	5.90	8.90	8.65
Nos. 22 and 24	5.25–8.02	10.25@11.55	6.05	9.05	9.05
No. 26	5.40–8.20	10.40@11.70	6.20	9.20	9.20
No. 28	5.70–8.50	10.70@12.00	6.50	9.50	9.50

*For painted corrugated sheets add 30c. per 1000 lb. for 5 to 28 gage; 25c. for 19 to 24 gages; for galvanized corrugated sheets add 15c., all gages.

STEEL AND IRON—The following discounts are to jobbers for carload lots on the Pittsburgh basing card, discounts on steel pipe, applying as from January 14, 1920, and on iron pipe from January 7, 1920:

BUTT WELD

Inches	Black	Galv.	Inches	Black	Galv.
¼ to 3	57 @54	44@41½	⅜ to 1	34½@24½	18½@ 8
			1¼ and 2	33½	17½
			2½....		

LAP WELD

2	50½@47	38@34½	2	28½@20½	14½@ 6½
2½ to 6	53½@50	41@37½	2½ to 6	30½@22½	17½@ 9½
7 to 12	50½@47	37@33½	7 to 12	27½@19½	14½@ 6
13 and 14	41 @37½	.....			
15	38 @35	.....			

BUTT-WELD, EXTRA STRONG, PLAIN ENDS

⅜ to 1½	55½@52	39½	⅜ to 1¼	34½@24½	19½@ 9½
2 to 3	56½@53	44@40½	2 and 2½	34½@24½	19½@ 9½

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	48½@45	37@33½	2	29½@21½	16½@ 8½
2½ to 4	51½@48	40@36½	2½ to 4	31½@23½	19½@11½
4½ to 6	50½@47	39@35½	4½ to 6	30½@22½	18½@10½
7 to 8	46½@43	33@29½	7 to 8	22½@14½	10½@ 2½
9 to 12	41½@38	28@24½	9 to 12	17½@ 9½	5½@ 5½

BOILER TUBES—The following are the prices for carload lots, f. o. b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	40½	3½ to 4½ in.	15½
2½ to 3¼ in.	30½	3 to 3½ in.	1
2¼ in.	24	2½ to 2¾ in.	+ 1
1¼ to 2 in.	19½	2 to 2¼ in.	+16
		1¾ to 1¼ in.	+29

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$327	1¼ in.	$207
1½ in.	267	2 to 2½ in.	177
1¾ in.	257	2¾ to 3¾ in.	167
1½ in.	207	4 in.	187
		4½ to 5 in.	207

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiations.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

	Net List
Less than coil lots	10%
Coils to 1,000 ft	15%
1,000 ft. and over	

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.45
12 to 50	.38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUITS, ELBOWS AND COUPLINGS—These prices are f. o. b. New York with 10-day discount of 5 per cent.

	Conduit		Elbows		Couplings	
Size, In.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.
¼	97.01	103.18	24.20	25.26	2.65	8.10
⅜	128.48	136.82	32.20	33.65	8.92	7.42
½	189.92	202.26	47.14	49.80	12.73	14.58
¾	256.96	273.05	60.02	63.26	16.56	17.50
1	307.24	327.20	80.02	84.35	22.75	23.89
1¼	413.36	440.24	145.63	154.63	28.10	29.52
1½	653.57	699.60	240.00	253.04	37.35	39.36
2	854.67	910.20	640.22	674.78	53.35	56.23
2½	1,060.94	1,127.74	1,433.83	1,494.60	80.03	112.46
3	1,283.15	1,362.53	1,633.90	1,722.10	106.70	140.58

Standard lengths rigid, 10 ft. Standard lengths flexible, ¼ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
⅜	250	$0.05½
½	250	.06
⅝	250	.09
¾	200	.12
⅞	200	.15
1	150	.18
1	100	.25
1¼	100	.33
1½	Odd lengths	.40
2	Odd lengths	.55

Coils....40% off
Less coils, 25% off

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.11	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	.....
T. P. S. B.	.81	1.80	.....
D. P. D. B.	.78	2.10	.....
T. P. D. B.	1.35	3.60	.....
T. P. to D. P. D. B.	.90	2.52	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$22.00
No. 16 cotton twisted	27.00
No. 18 cotton parallel	26.50
No. 16 cotton parallel	34.50
No. 18 cotton reinforced heavy	34.00
No. 16 cotton reinforced heavy	42.00
No. 18 cotton reinforced light	30.00
No. 16 cotton reinforced light	36.75
No. 18 cotton Canvasite cord	28.50
No. 16 cotton Canvasite cord	32.00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
110-amp. to 200-amp.	25	2.00
225-amp. to 400-amp.	25	3.60
425-amp. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package 30%
1-5th to standard package 40%
Standard package 52%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$4.75C
0-30 ampere, less than standard package	6.00G

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B—				Pear-Shaped Bulbs Mazda C—			
Watts	Plain	Frosted	No. in Package	Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.25	24
25	.40	.45	100	150	1.55	1.70	24
40	.40	.45	100	200	2.10	2.30	24
50	.40	.45	100	300	3.15	3.40	24
60	.45	.50	100				12
				500	4.60	4.90	12
				750	6.50	6.90	8
				1,000	7.50	7.95	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

		Each
Hubbell porcelain No. 5406,	standard package 250	$0.24
Hubbell composition No. 5467,	standard package 50	.32
Benjamin swivel No. 903,	standard package 250	.20
Hubbell current taps No. 5638,	standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$12.00	$16.00	$13.90	$28.50
12	13.25	15.70	18.05	30.70
10	18.30	21.00	23.85	41.50
8	25.54	28.60	32.70	56.77
6	.....	.....	51.40	.....
4	.....	.....	70.00	.....
2	.....	.....	101.80	.....
1	.....	.....	131.86	.....
0	.....	.....	160.00	.....
00	.....	.....	193.50	.....
000	.....	.....	235.20	.....
0000	.....	.....	288.60	.....

Prices per 1000 ft. for Rubber-Covered Wire in Following Cities:

	Birmingham			St. Louis		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$12.23	.....	$38.64	$14.85	.....	$37.25
10	27.60	.....	65.57	23.45	.....	57.20
8	38.64	.....	87.33	32.10	.....	.....
6	69.12	.....	.....	.....	55.10	.....
4	.....	107.42	.....	.....	73.75	.....
2	.....	138.46	.....	.....	103.10	.....
1	.....	178.52	.....	.....	133.30	.....
0	.....	217.09	.....	.....	159.90	.....
00	.....	263.57	.....	.....	189.20	.....
000	.....	320.44	.....	.....	225.10	.....
0000	.....	389.17	.....	.....	269.30	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap			⅜ In. Cap		
Key Each	Keyless Each	Pull Each	Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package +50%
1-5th to standard package +20%
Standard package —10%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	55c. lb
No. 18 B. & S. regular 1-lb. coils	56c. lb

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 60c. lb., 100 lb. lots	55c. lb
Rubber tape, ¾ in., less 100 lb. 65c. lb., 100 lb. lots	60c. lb
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb
Soldering paste, 2 oz. cans Nokorode	$1.20 doz

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	+25%
$10 to $25 list value	+10%
$25 to $50 list value	+5%
$50 to $200 list value	—10%
$200 list value or over	—15%